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NUTRITIONAL AND HYDRATION STATUS OF SPECIAL FORCES SOLDIERS CONSUMING THE RATION, COLD WEATHER, OR THE MEAL, READY-TO-EAT RATION DURING A TEN DAY COLD WEATHER FIELD TRAINING EXERCISE

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Four teams of Special Forces volunteers were divided into two groups to test the Meal, Ready to Eat (MRE) and the Ration Cold Weather (RCW) rations in a field test in a moderately cold environment. The MRE group was allowed to select their 10 day food supply from an issue of 4 MRE's per day. The RCW group carried the entire ration into the field. Pre and post measurements were taken, and field data was limited to questionnaires and a daily urine dip-stick measure. Both groups lost weight (MRE - 6.9 lbs; RCW - 5.9 lbs) as the average caloric intake was 2733 kcal for MRE group and 2751 kcal for RCW group. These caloric intakes were approximately 1000 kcal less than their estimated energy requirements. Both groups showed evidence of dehydration (as indicated by elevated urinary specific gravity) which could have been reduced by better water discipline. The RCW ration consumption led to lower protein, lower salt and higher carbohydrate intakes than the MRE ration. The daily RCW ration (4541 kcal) weighs about half as much as a comparable caloric amount of MRE rations (4 rations = 4892 kcal). There did not appear to be any significant difference in the consumption of the

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two rations, but the theoretical decrease in water requirements due to lower protein and salt content and the decreased weight make the RCW a better choice for use in cold environments where freezing, water availability, and weight are important considerations. The results of this study indicated that although the RCW supported soldier performance in this FTX similar to the MRE, it offered no improvement in reducing weight loss, increasing calorie intake or hydration status compared to the MRE. A future version of the RCW should maintain the present carbohydrate level, but reduce the sugar content by reducing the bar/cookie components, and include items to encourage fluid consumption.

DISCLAIMER STATEMENT

The views, opinions, and findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

Human subjects participated in these studies after giving their free and informed consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 in Use of Volunteers in Research.

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Nutritional and Hydration Status of Special Forces Soldiers Consuming the Ration, Cold Weather or the Meal, Ready-to-Eat Ration During a Ten Day Cold Weather Field Training Exercise

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ABSTRACT

Four teams of Special Forces volunteers were divided into two groups to test the Meal, Ready to Eat (MRE) and the Ration Cold Weather (RCW) rations in a field test in a moderately cold environment. The MRE group was allowed to select their 10 day food supply from an issue of 4 MRE's per day. The RCW group carried the entire ration into the field. Pre and post measurements were taken, and field data was limited to questionnaires and a daily urine dipstick measure. Both groups lost weight (MRE = 6.9 lbs; RCW = 5.9 lbs) as the average caloric intake was 2733 kcal for MRE group and 2751 kcal for RCW group. These caloric intakes were approximately 1000 kcal less than their predicted energy requirements. Both groups showed evidence of dehydration (as indicated by elevated urinary specific gravity) which could have been reduced by better water discipline. The RCW ration consumption led to lower protein, lower salt and higher carbohydrate intakes than the MRE ration. The daily RCW ration (4541 kcal) weighs about half as much as a comparable caloric amount of MRE rations (4 rations=4892 kcal). There did not appear to be any significant difference in the consumption of the two rations, but the theoretical decrease in water requirements due to lower protein and salt content and the decreased weight make the RCW a better choice for use in cold environments where freezing, water availability, and weight are important considerations. The results of this study indicated that although the RCW supported soldier performance in this FTX similar to the MRE, it offered no improvement in reducing weight loss, increasing calorie intake or hydration status compared to the MRE. A future version of the RCW should maintain the present carbohydrate level, but reduce the sugar content by reducing the bar/cookie components, and include items to encourage fluid consumption.

INTRODUCTION

The Marine Corps has established a required operational capability (ROC) for a 4500 kcal operational arctic ration (subsequently designated the Ration, Cold Weather). The Marines have found that current rations are deficient for cold weather operations because they are too bulky and heavy and water content makes them susceptible to freezing. Frozen rations accentuate the problems of hypothermia and dehydration and may compromise package barrier protection. The Marine arctic ration prototype has been evaluated during NATO winter exercises (1-3), in a climatic chamber test (4), by the Navy Seal Team (5), by the U.S. Army Health Clinic, Ft. Greely, Alaska (6), and by the Cold Regions Test Center, Ft. Greely, Alaska (7).

The U.S. Army Quartermaster School has initiated a draft letter requirement (DLR) for the Ration Cold Weather (RCW).

Previous field tests (2,6,7) of the RCW (formerly Arctic Ration) have identified suboptimal caloric intakes and dehydration as potential shortcomings of the RCW (as well as other packaged rations). Other tests failed to record either food intake or body weight loss (1,3,6,7) and no tests have included the effect of the RCW on nutritional status or muscle strength and endurance. For these reasons, it was decided to conduct a technical feasibility test of the RCW with elements of the 3rd Bn, 10th Special Forces (A) Ft. Devens, MA during their winter warfare training in the White Mountains of New Hampshire. This test was designed to collect blood and urine samples, body weights, conduct muscle strength testing, and measure body fat pre and post 10 day field training exercise (FTX) and record food and fluid intakes daily. This data would permit a reasonable evaluation of energy balance and nutritional and fluid status. A description of the RCW is enclosed in Appendix 1.

METHODS

Rations

The macro-nutrient composition of the MRE and RCW rations is shown in Table 1. MRE III produced in 1983 was used as the control ration. This ration contained both hydrated and dehydrated food items, whereas the RCW ration consisted entirely of dehydrated food items. Four MRE's per man per day (4892 kcal) were issued to the control (MRE) subjects and 1 RCW per man per day (consisting of two packets containing 4541 kcal) was issued to the test (RCW) subjects. This was done to approximately equalize calories available per man per day. Because 4 MRE's per man per day are rather bulky, the MRE group was resupplied on day 5. The soldiers placed 5 days of rations in their packs and prepared another 5 days worth of ration components to be delivered to them in the field. The MRE group was permitted to break down the packaged meals into their components and choose as many of these components to take or be supplied with on day 5 as they desired. (This is normal SOP with these soldiers on this type of FTX). The food items that the MRE group left behind were inventoried. This showed that the MRE group chose to take approximately 70% out of each days ration of 4892 kcal. This meant that the MRE group had an average of approximately 3400 kcal/man/day at their disposal while in the field. The RCW group, on the other hand took 10 days of complete rations without breaking them down since they had no prior experience or familiarity with the ration to decide which components to take or leave behind. MRE components taken and returned were inventoried to permit interpretation of MRE food component desirability.

Test Subjects

Four Special Forces teams were randomly assigned to ration groups, two teams to each ration. Initially there were 20 men assigned to the MRE ration and 18 men assigned to the RCW ration. This was reduced to 16 and 18, respectively, by the end of the FTX due to injuries and administrative necessities. The data presented in this report represents the means for 16 and 18 men per group. All subjects were briefed on the purpose of the test and familiarized with the rations and signed volunteer consent forms.

Experimental Design

The field test was conducted during the 10th Special Forces Group Winter Warfare training in the White Mountain National Forest in New Hampshire in February 1986. The FTX began with a three day "lock-down" period at Ft. Devens when the soldiers began mission preparation. Pre-testing was conducted during days 2 and 3 of "lock-down". During the "lock-down" phase, soldiers were housed in heated barracks. The subjects began eating the rations on the first day of deployment (insertion) and thereafter for nine consecutive days. Day 10 was devoted to exfiltration and return to Ft. Devens and a final period of lock down for de-briefing and post-testing. Pre- and post-testing included body weight, anthropometry, muscle strength and endurance, and blood and urine sampling.

The soldiers parachuted into a rugged mountainous region and traveled by skis over distances of 7-16 km during a 4 day time period until they had reached their team objective. The terrain was cross country, mountainous and forested. Each soldier carried a 90 lb. pack. After 4-5 days of cross country skiing and snow shoeing, the soldiers remained relatively inactive for 3-4 days conducting surveillance missions with some short reconnaissance trips. The final 2 days were devoted to exfiltration (approximately 9 km) and airlift by helicopter back to Ft. Devens.

The activity level of the teams was similar, but somewhat variable depending upon the terrain in which they were inserted. The activity level was high during insertion and exfiltration due to the demands of skiing, snowshoeing, hiking and climbing across the rugged terrain. The activity level was relatively sendentary during the mid part of the exercise. Energy expenditure could not be measured during the test, but was estimated at an average of 3950 kcal/man/day by records of activity and interview with the subjects following the test.

The terrain was snow covered with depths ranging between 18-26 inches of snow. There was some snow fall on 3 of the 9 days. Temperatures ranged from 0-5°F at night to 20-35°F during the day.

Anthropometry

Subjects were weighed in stocking feet with T-shirts and PT-shorts before and after the 10 day FTX using a calibrated electronic digital balance accurate to ± 0.1 lb. Percent body fat was estimated by skin fold thicknesses according to the method of Durnin and Womersly (8). Each site was pinched 3 times and the mean value used in the calculation of percent body fat. Pre-Post changes in body weight and % body fat were calculated and the Δ was used as the figure of merit in comparing the two ration groups. The same army credentialed anthropometrist performed all skinfold measurements pre and post experiment.

Muscle Strength and Endurance

Muscle strength testing was performed using the Cybex II isokinetic dynamometer. Subjects were seated in a padded chair with restraining straps at the waist and distal portion of the thigh. The subject was attached to the lever arm of the machine by means of a padded leg cuff approximately 2.5 cm above the malleolus. The axis of rotation of the Cybex dynamometer lever arm was adjusted vertically and horizontally to align with that of the subject. Right leg extension strength was measured at 30°/sec and 180°/sec. The mean of three maximum leg extensions within a 10% range was accepted as the maximum isokinetic strength at each speed (9). The Thorstensson test of muscular endurance consisted of 50 consecutive maximal leg extensions at an angular velocity of 180°/sec over 60 seconds (10). The following measures were derived from the 50 contraction series (11).

Highest peak torque (HPT) (Nm) = Mean of first four contractions

Mean peak torque (MPT) (Nm) = Mean of 50 contractions.

Decline in peak torque (DPT) (%) $= \dfrac{\text{HPT} - \bar{X} \text{ last four contractions} \times 100}{\text{HPT}}$

HPT and MPT were also divided by body weight (kg) to normalize torque for body size.

Subjects were allowed several submaximal practice contractions prior to actual data collection. The data collectors verbally encouraged subjects to exert maximum effort with each contraction.

Food and Water Intakes

Subjects were issued pocket sized log books with a complete listing of food items with separate data sheets for each day of the test (Appendix 2). These forms were designed to require minimal effort for compliance and could be filled out wearing gloves. Subjects merely had to find the food item consumed and circle the quantity of the food item they consumed along with quantities of water used to prepare the food items and water consumed directly from canteens. Each soldier carried 2 one quart canteens and depended upon ground water for refilling the canteens. Water was readily available by breaking ice on streams or melt off from snow. Soldiers carried commercial backpacking stoves and fuel for heating water. Subjects were instructed by trained dietitians prior to the test in how to record food and water intakes and were interviewed by these same dietitians at the end of the test to verify food and water records. As a check on the degree of compliance with log book food records, all subjects were instructed to save food wrappers and uneaten food portions in zip lock bags. These wrappers and uneaten food items were inventoried as a check against log book records. Log book records have been previously established as a reasonably accurate method of determining food intake of packaged rations (12). We found that the log book records were more complete than the wrapper collections suggesting that soldiers were more thorough in marking down food items in a log book than they were in saving wrappers. Wrapper collections averaged 65% of log book entries.

This is probably a reflection of the onerous nature of saving food wrappers for extended times in the field but may have helped ensure compliance in log book notations. Wrappers were not used to adjust food intakes recorded in the log books since the incidence of finding a wrapper without a corresponding entry in the log book was low.

The two ration groups were physically separated from each other in the field and could trade food items within ration groups if they desired as long as they recorded what they ate. Packs were inspected prior to deployment to ensure no other food items were taken to the field. Foraging was not permitted.

Nutrient Intakes

Food item consumption was factored against known energy, protein, carbohydrate, fat, and sodium contents of each food item. Further vitamin and mineral composition data was available for the MRE ration, but not the RCW ration, hence only these nutrient intakes are reported. The RCW was fortified to meet the Nutritional Standards for Operational Rations (NSOR) of AR 40-25 (13) with the exception of sodium, which was purposely set at a lower level (4500 mg

Na^+) than the MRE (7000 mg Na^+) to reduce the water burden of this ration. Nutrient intakes were calculated both per group per day and as a 9 day group means.

Nutritional Status

Venous antecubital blood samples were taken after an overnight fast upon rising at 0600 hrs the morning of day 1 and the morning of day 10 while the soldiers were still in the field. The samples were permitted to clot and then centrifuged to prepare serum for a standard clinical panel of blood chemistries. Urine dipsticks (N-Multistix (R), Ames Division, Miles Laboratories) were isssued to each test subject with the instructions to monitor the ketone (acetoacetone) and specific gravity of their first void urine each morning and to record these values in their log book (Appendix 3). Although these tests are only semi-quantitative, they did provide some information on the degree of ketosis (negative energy balance) and degree of concentrated urine (dehydration) that occurred in the field while the soldiers were inaccessible to our test team.

Hydration Status

Hydration status was assessed by examination of blood and urine profiles. Overnight fasting venous blood (24 ml) was collected at the beginning (during lock-down) and at the end of the nine day field exercise (morning of exfiltration prior to returning to Ft.Devens). The following parameters were measured on these blood samples:

1. Hematocrit
2. Hemoglobin
3. Serum aldosterone
4. Serum osmolality
5. Serum potassium
6. Serum sodium
7. Serum percent protein

Hematocrit was determined by the use of heparinized capillary tubes and read after spinning for 5 minutes on a Damon/IEC micro hematocrit centrifuge. Hemoglobin was determined by the cyanmethemoglobin method using a Gilford Stasar III spectrophotometer. Serum aldosterone was determined by radioimmunossay using a kit (coat-a-count) from Diagnostic Products Corporation. Serum osmolality was determined by the vapor pressure method using the Wescor model 5500. Serum potassium and serum sodium were determined on a Instrumentation Laboratory model 443 flame photometer, and were used only to compare to values obtained in the standard clinical blood chemistries. Percent protein was determined by use of a Reichert refractometer.

Blood volume, plasma volume, and total body water were calculated according to the following formula (24):

$$\text{Blood volume}_{pre} = 0.0236\ (\text{Height,cm})^{0.725}\ (\text{mass,kg})^{0.425} - 1.229$$

$$\text{Plasma volume}_{pre} = BV_{pre}\ \frac{(1 - (Hct_{pre} * 0.96))}{100} * 1000$$

$$\%\ \Delta\ \text{Plasma volume}_{post} = \left(\frac{100}{100-Hct_{pre}}\right) \left(\frac{100(Hct_{pre} - Hct_{post})}{Hct_{post}}\right)$$

$$\text{total body water}_{pre} = (0.60)\ (\text{body wt-kg})$$

$$\text{total body water}_{post} = (TBW_{pre})\ \frac{(\text{Serum sodium}_{pre})}{(\text{Serum sodium}_{post})}$$

notes: All Hct measurements corrected for trapped water by multiplication by 0.96. Serum sodium concentration in milliequivalents per liter.

A first-void-in-the-morning urine sample was obtained at the same time the blood was drawn. This urine sample was analyzed for:

1. potassium
2. sodium
3. specific gravity

Urinary sodium and potassium concentrations were measured on an Instrumentation Laboratory model 443 flame photometer. Urine specific gravity was determined by use of Reichert total solids meter and by Ames N-multistix test strips. During the nine-day field test, a daily first void urine was collected by the team medic and specific gravity measured by use of Ames N-multistix test strips.

Blood Pressure

Arterial blood pressure was obtained in two modes (sitting and standing) during the "lock-down" and upon return from the field. The ausculatory method was used and repetitive measures taken by the same trained individual.

Statistical Method

Data for each parameter was grouped according to the ration consumed (MRE or RCW) and analyzed by either paired t-test or ANOVA with repeated measures. Probabilities of less than 0.05 were considered significant. All values shown represent the mean $\pm$ SEM.

RESULTS

Body Weight and Percent Body Fat Changes

A comparison of body weight and percent body fat changes is shown in figures 1 and 2. Both ration groups lost a significant amount of body weight (MRE-4%; RCW-3%) but there was no significant difference in weight loss between the two groups (6.9 $\pm$ 0.6 vs. 5.7 $\pm$ 0.9 lbs, MRE vs. RCW, respectively).

The MRE group lost significantly more body fat than the RCW group (-1.98 ± 0.28 vs. $-0.91 \pm 0.18\%$, respectively). The differences in body fat loss may relate to the greater initial percent body fat of the MRE group compared to the RCW group.

It is impossible to determine the exact component of the body weight loss in this study, but it was calculated that approximately 50% of the weight loss for both groups was body fat. The remaining portion of the weight loss could have been due to loss in lean body mass or loss of body water. The protein intakes recorded in this study (see nutrient intake section) argue against the former and the hydration status of the soldiers (see hydration status section) argues in favor of the latter.

Muscle Strength and Endurance

Complete data was obtained on 16 subjects in the MRE group and on 15 subjects in the RCW group. Partial data was obtained on an additional three men in the RCW group. In order to establish initial group equality a t-test was used to compare the strength and endurance of the two groups. As no significant differences were found, the isokinetic strength and endurance of the two groups were deemed equivalent at the beginning of the study. Table 2 illustrates the isokinetic strength and endurance measures obtained from each group before and after the 10 day scenario. Compared to similar populations of soldiers, maximum torque produced at 30°/sec and 180°/sec was somewhat higher in the MRE group and about average in the RCW group. Highest Peak Torque (HPT) of both groups was at the upper end of reported values, Mean Peak Torque (MPT) was about average and Decrease in % Peak Torque (DPT) was below average. Comparison values are listed in Table 3. This indicates that the 10th Special Forces groups tested were strong (HPT), but had poor muscular endurance (DPT).

There were no significant group or interaction effects in any of the strength or endurance measures. Isokinetic strength at 30 and 180°/sec was not significantly different pre and post scenario. In agreement with this, HPT did not change from pre to post scenario. With the exception of HPT, all isokinetic endurance measures demonstrated a significant effect over time. As there were significant time effects, the changes in muscular endurance cannot be attributed to the ration. This time effect could be from either a training effect produced by the field exercise, or from learning to perform the Thoustensson test.

These results indicate that both MRE and RCW groups received adequate nutritional intake to maintain isokinetic strength. Based on MPT and DPT, the soldiers actually improved their isokinetic endurance. Whether this was due to a training or learning effect is not known.

Nutritional Intakes

Daily nutrient intakes of calories, protein, carbohydrate and fat are shown in figures 3, 4, 5 and 6 respectively. Mean 9 day intakes for these same nutrients are summarized in figure 7 and mean sodium intakes are shown in figure 8. Daily caloric intakes for both groups were generally comparable, except for day 1, when the caloric intake was unexplainably low for the MRE group. This may have been related to differences in operational requirements between groups on the day of insertion. Although both groups were following similar training scenarios, there were operationally necessary differences in times of departure and terrain obstacles encountered after parachuting into the field. Protein and fat intakes were generally lower and carbohydrate intakes higher for the RCW group on a daily basis. These data are summarized in figure 7. Mean kcal intake for the 9 days was 2733 $\pm$ 65 for the MRE group and 2751 $\pm$ 70 for the RCW group. This difference was not statistically significant, and both groups consumed less energy than the 4500 kcal/day recommended for troups engaged in heavy physical activity during cold weather operations cited in AR 40-25. The MRE group consumed 99 $\pm$ 2 g of protein/man/day which was adequate to meet the 100 g/day Military Recommended Dietary Allowance (MRDA); however the RCW group consumed 83 $\pm$ 2 g protein/man/day, which exceeded the NAS/NRC RDA of 56 g of protein/day (14), but did not meet the MRDA. The RCW group consumed significantly more carbohydrate than the MRE group (384 $\pm$ 11 vs. 302 $\pm$ 8 g/man/day, respectively). There is no MRDA for carbohydrate. Intakes in excess of 400 g/man/day are usually adequate for glycogen repletion. Fat intakes for both groups were well below the 160 g/day maximum recommended by the MRDA with the RCW group consuming significantly less fat than the MRE group. The RCW group consumed significantly less sodium (3535 $\pm$ 75 mg/man/day) than the MRE group (4859 $\pm$ 135 mg/man/day). Both sodium intakes were below the range (5000-7000 mg/day) recommended by OTSG for operational rations, but were greater than the 1100-3300 mg range published in the NAS/NRC RDA as safe and adequate levels.

Trace amounts (approximately 2.0 mg/dl) of acetoacetone was detected in the urine samples by the daily urine dipsticks. Although some daily differences were noted in urine dipstick ketones, there was no significant difference between groups in mean daily urinary ketones averaged over the 10 day FTX (figure 9). The presence of a small amount of ketones in the urine indicates a caloric deficit requiring body fat mobilization and oxidation and is consistent with the body fat losses and energy intake values summarized in figures 2 and 7. Daily urine ketones were generally highest on days 2-6 when the greatest physical work was performed in the cross country movement. The MRE group achieved a peak value of 10.9 mg/dl on day 2, further corroborating the low caloric intake figures reported for that group on day 1. The RCW group had a mean reading of 0.8 mg/dl on that same day.

Nutritional Status

Blood chemistries are presented in figures 10-21. Each chemistry will be discussed separately. Normal values and the clinical significance of abnormal values have been taken from references by Tietz (15) and Grant (16). Pre vs. post changes in blood chemistries within ration groups were compared by a paired T-test. In this manner, each group served as its own control. Between ration statistical comparisons were accomplished by an ANOVA.

1. Blood glucose, figure 10: Blood glucose is normally regulated over a relatively narrow range of 70-105 mg/dl. Both groups displayed normal pre and post study blood glucose levels with no significant differences Pre vs. Post. This indicates blood glucose was well regulated and subjects were not hypoglycemic.

2. Blood urea nitrogen, figure 11: Blood urea nitrogen (BUN) occurs over a normal range of 7-18 mg/ml. Elevated values occur with increased protein breakdown (such as that occuring in starvation, stress, or dehydration). Decreased values are associated with both decreased protein ingestion and overhydration. The MRE group displayed slightly higher than normal BUN both pre and post FTX. RCW BUN values fell within normal values, although there was a significant increase in BUN in the RCW post sample. This increase is difficult to interpret due to the relative low pre-value. Two interpretations are possible. The post-value could be elevated due to increased protein breakdown triggered by a reduced energy intake. This seems unlikely since the energy intakes of the MRE and RCW groups were practically identical and a similar response was not seen in the MRE group.

Alternatively, the pre-value for the RCW group could have been lower due to overhydration thus creating an artificially lower BUN. In fact, the pre-FTX urine specific gravities were somewhat lower for the RCW group, adding some plausibility to this explanation (refer to section on hydration status). Regardless of the stimulus for the change in BUN in the RCW group, it should be remembered that the change was relatively small and both pre and post values fell within the normal range of values.

3. Triglycerides, figure 12, and cholesterol, figure 13: Elevated levels of both cholesterol and triglycerides in plasma are considered risk factors in atherosclerotic disease. The levels of blood triglycerides and cholesterol can vary independently (i.e. in response to certain types of carbohydrate in the diet) but usually are increased by a high intake of dietary fat of animal origin or decreased by reduced dietary fat and exercise. Normal values for serum triglycerides are 30-160 mg/dl and for serum cholesterol 140-250 mg/dl. All values for both rations pre and post fell within the normal range. All post values for triglycerides and cholesterol were significantly reduced pre to post experiment, probably due to the negative caloric balance (the relatively low level of fat intakes) and the physical exertion associated with the FTX.

4. Sodium, figure 14: Sodium is the major cation of extracellular fluid and plays a critical role in the maintenance of water distribution in the various fluid compartments. The nutritional significance of sodium in the blood is difficult to interpret since the body content of sodium is not always reflected by blood levels. The level of sodium in blood is closely regulated by the kidney and relatively small variations in the concentrations of sodium are usually observed in healthy subjects. Although pre and post

sodium values for both groups fell in the normal range of 135-148 m mol/L, both ration groups had a small but significant increase in post FTX serum sodium. This was probably related to the degree of dehydration and hence reduced plasma volume found in the subjects at the end of the FTX (refer to section on hydration status).

5. Potassium, figure 15: Serum potassium is not a good index of body potassium status, but is presented because it does contribute to serum osmolality, albeit not as significantly as sodium. Normal values are 3.5-5.3 m mol/L. All values fell in the normal range and there were no significant changes during the course of the FTX.

6. Chloride, figure 16: Chloride is the major extracellular anion and is a major determinant of water distribution, osmotic pressure, and normal anion-cation balance in the extracellular fluid compartment. Elevated serum chloride values occur in dehydration or with excessive intake of chloride salts such as sodium chloride. Normal serum chloride values range from 98-106 m mol/L. All values for both ration groups fell within this normal range. As was the case for sodium, there was a small but significant increase in chloride in the post sample in both ration groups, probably related to dehydration (see section on hydration status).

7. Phosphorous, figure 17 and Calcium, figure 18: The metabolism and regulation of calcium and phosphorous are closely related. These minerals are involved in many diverse metabolic processes and reciprocal relationships of serum levels of these minerals is commonly observed. Hypocalcemia can, however, be observed with both normal or increased serum phosphorous levels. Normal ranges for serum phosphorous are 3.0 - 4.5 mg/dl and 8.5 - 10.4 mg/dl for calcium. All values observed for both

ration groups fell within normal ranges. There were significant decreases in phosphorous in both ration groups. The reason for these decreases is not apparent, but may be related to a decreased intake of phosphates during the FTX when carbonated soft drink beverages (which are high in phosphates) were not available. The small but significant increase in serum calcium in the MRE but not the RCW group is also unexplainable and probably of little nutritional significance. The calcium intakes of the MRE groups averaged 632 mg/day or 79% of the MRDA. Calcium content of the RCW was not furnished and hence its value cannot be compared to that of the MRE group.

8. Protein, figure 19, albumin, figure 20 and globulin figure 21: In general, serum proteins can be considered indicators of body protein status but are usually better indicators of severe protein malnutrition than temporary nitrogen imbalance which is better detected by nitrogen balance studies. Serum albumin is a better indicator of protein status than total protein. Globulins are often elevated by dehydration, but the albumin to globulin ratio should remain constant if dehydration is causing a shift in concentrations of blood proteins. All values reported for serum proteins fell in the normal range, although the MRE group displayed small but significant increases in blood proteins at the completion of the test. This might be explained if the degree of dehydration was greater in the MRE group than the RCW group, but this did not seem to be the case (refer to section on hydration status). There were no significant changes in albumin to globulin ratio pre vs. post for either group. This is consistent with but not necessarily indicative of dehydration.

Food Item Component Preferences

The MRE group was permitted to break down the 4 MRE meals/day (40 total meals) allotted to them into individually packaged components and take whatever items with them that they desired. A food item inventory was made to permit calculation of the percent of items available that were selected to be taken on the FTX. A subsequent calculation of the percent of food items taken that were actually consumed was also made and presented along with the selection data in figures 22-28. The statistical significance of these choices was not evaluated and is presented as purely descriptive data. The 12 MRE entrees (figure 22) were taken at similar frequencies, however, the turkey/gravy and the frankfurter entrees appeared to be consumed to a greater extent (73-75%) than the beef/gravy and the beef/spiced sauce entrees (54-58%). Approximately 70% of the entrees available were taken, and a similar proportion of those taken were consumed. Of the starches (figure 23), the potato patty, beans, and crackers were taken in similar proportions, but the potato patty was consumed to a greater degree (70%) than the beans or crackers (48-53%). The selection and consumption rates of the desserts are shown in figure 24. The most popular dessert item was the chocolate covered cookie which was consumed at an 84% rate compared to the pineapple nutcake which was consumed at only 51%. The 3 spreads (figure 25) were all taken and consumed in similar amounts. The mixed fruit, for reasons that are not clear, was selected at a lower rate but consumed at a higher rate than the other fruits (figure 26). Cocoa proved to be a more popular beverage than coffee (figure 27), although it should be realized that coffee occurred in every meal whereas cocoa occurred in only 60% of the meals. It is worth noting that although 70% of the available salt packets were taken, only 1% of the salt packets taken were consumed.

The RCW group was required to take the complete ration to the field with them, hence the category of percent taken is not presented, but the percent selected to be eaten of what was available was calculated and presented in figures 29-35. The RCW entrees appeared to be divided into two consumption patterns. The chicken stew bar, the chicken rice bar and the pork and escalloped potatoes were consumed at slightly higher rates (88-90%) than the other three entrees (75%) (figure 29). The granola cookie bar was consumed at the highest (72%) rate for the desserts whereas only 47% of the chocolate toffee bar was consumed (figure 30). All three oatmeal cereals were consumed at the same rate (figure 31). The beverage consumption is shown in figure 32. As was the case with the MRE, the cocoa was consumed to a greater degree (42%) than the cocoa (20%). The orange beverage bar was not avidly consumed (23%) compared to cider(45%). The fruit soups were not well consumed compared to chicken noodle soup (figure 33) or cider, or cocoa. Condiments were all consumed at similar low rates (figure 34). No salt packet was offered in the RCW.

Hydration Status

The state of hydration is inferred from measures of blood and urine chemistries and calculation based on anthropometric measures.

Table 4 shows the individual hematocrit values and means for both groups pre and post tests. These fall within normal limits and there is no change from the pre test values to the post test values.

Table 5 lists the individual and mean values for serum aldosterone for both ration groups. This mineralocorticoid plays an important role in the regulation of sodium and potassium balance. There is no significant differences between groups or within groups between tests. This indicates that the kidneys are working normally to maintain blood levels of sodium and potassium in the face of increased sodium consumption for the MRE ration (figure 8) as compared to the RCW.

Serum osmolality (Table 6) reflects the concentrations of osmotically active particles i.e., sodium, potassium and chloride as well as serum protein. There were no differences between groups, but there was a significant drop ($p<0.05$) in the MRE group from the pre test to the post test.

Tables 7 and 8 shows the calculated values for blood volume, plasma volume and total body water. Comparisons of the pre blood volumes for the two groups shows no differences. Also there is no difference between groups with plasma volume or total body water. The calculated values within the ration groups shows no difference in total body water between pre and post measurements indicating that dehydration was mild or nonexistent.

Figure 35 shows the mean values for pre and post urinary specific gravity. There is a slight difference (not significant) between the groups before the FTX, but each group shows a significant change during the FTX. Figure 36 shows the daily values taken from dipstick measures. Dipsticks are inherently less accurate since they are colormetric tests and read in increments of 0.005 with a maximum value of 1.030. The two groups urine specific gravities followed a similar pattern during the FTX with the RCW group having a higher specific gravity at the end of the FTX.

Figure 37 shows the mean values for urinary sodium for each group.The significantly higher excretion of sodium by the MRE group would be expected since that ration has a higher salt content and all other data indicates normal kidney function.

Figure 38 shows the mean values for urinary excretion of potassium. The urinary excretion of potassium is elevated for both groups. There are no normal ranges for urinary excretion of either sodium or potassium, but greater excretions in normal kidneys would be the result of increased intake or dehydration.

Blood Pressure

Tables 9 and 10 list the mean values for heart rate, systolic pressure, and diastolic pressure for each ration group for both standing and sitting. There are small increases in the heart rate from pre to post for each mode except for the RCW group while sitting. This group also shows no change in the systolic pressure while all other groups shows an increase from pre to post.

DISCUSSION

The routine laboratory blood and urine tests used in this study are useful but not conclusive in assessing nutritional status. For example, serum albumin can be used as an index of protein status and blood urea nitrogen can be used as an index of an imbalance between protein intake and breakdown of body protein reserves. However, neither of these two tests are conclusive in and of themselves and require 24 hour food intakes and urine collections to determine nitrogen (protein) balance to permit a definitive evaluation. In this study, we were able to make relatively good 24 hour estimates of food intakes by the log book and interview technique and collected pre and post blood chemistries to assist in evaluation of nutritional status. These values, when integrated with body weight changes, changes in percent body fat and hydration status can furnish a good estimate of nutritional status in the absence of metabolic ward conditions and more rigorous and definitive blood tests. It should be realized that 24 hour urine collections and accurate estimates of energy expenditure were not possible within the operational constraints of this FTX and their absence precludes a more accurate evaluation of nutritional status. The results will be discussed topically by nutritional indicator:

Body Weight and Percent Body Fat Changes and Muscle Strength and Endurance

The weight loss for this 10 day FTX was moderate and similar for both ration groups and did not affect muscle strength and endurance. The MRE group lost 4% of their initial body weight and the RCW group lost 3%. Studies on caloric restriction and weight loss suggest that physical performance is relatively well maintained up to a 10% loss of body weight (17). The RCW was no better or no worse than the MRE ration in maintaining body weight. Neither ration was consumed in adequate quantities to meet energy demands and maintain body weight. Although isokinetic muscle strength and endurance was maintained in this study, aerobic endurance capacity was not tested. The greater carbohydrate intakes of the RCW group (384 g/man/day) compared to the MRE group (302 g/man/day) should have supported maintenance of muscle and liver glycogen to a greater degree; however, it is impossible to say if this difference would have been great enough to enhance aerobic endurance. The 6-7 lb weight loss encountered for both rations in this study is acceptable over a 10 day time period, but continued weight loss at this rate for time periods greater than 10 days might be detrimental to performance. Indirect estimates indicate that as much as 50% of the weight loss could have been due to dehydration. Although severe dehydration was not present, better water discipline should result in even smaller 10 day body weight losses.

Nutritional Status

The intake of energy for the two ration groups was remarkably similar and was 76% of the MRDA (upper range of moderate activity) of 3600 kcal/man/day. We estimated caloric expenditure (based upon interviews with the subjects taking into consideration body mass, pack weight and percent of time spent skiing, snowshoeing, walking and resting) to be approximately 3950 kcal/man/day. Actual caloric intakes were 70% of this estimate (approximately 1000-1200 kcal/day below energy demands). This level of energy deficit would be consistent with approximately a 3 lb body weight loss. This was about 1/2 of the actual weight loss observed, suggesting that the remainder may have been due to inadequate hydration. The weight loss data and the appearance of small amounts of ketones in the daily urine samples supports the contention that the subjects were in negative caloric balance. The failure of the subjects to eat to energy requirements was not due to a lack of food items for consumption and has been observed in other field studies testing both the MRE (12) and the RCW rations (6). The energy intakes of both the MRE and RCW groups of this study agree closely with those noted in previous tests of these rations. The reason(s) for less than adequate caloric intakes of packaged operational rations is not known; however a recent 8 day field study of field artillery troops engaged in continuous operations fed 3 hot A rations per day demonstrated that the soldiers ate to caloric demands and maintained body weight (18). This implies that ration palatability or other factors associated with consuming packaged rations contribute to sub-adequate energy intakes noted in some field studies. The recent test of the RCW ration during the Denali Ski March in Alaska did not report food consumption or energy intakes but noted only small (3 lb) weight loss over the 10 day test, indicating that under those conditions, energy intake was more closely related to energy expenditure and that ration palatability was sufficiently high to insure adequate caloric intake (7).

The protein content of the RCW ration was formulated to provide a reduced, but adequate amount of protein in the diet. Protein consumed above nitrogen requirements is oxidized for energy and the nitrogen in the form of urea must be excreted. This requires 40-60 ml of water for each gram of urea nitrogen excreted (19). The RCW group consumed 16 g of protein (2 1/2 g of nitrogen) less per day than the MRE group. The RCW group, all other factors being equal, would require (2 1/2g N x 50 ml H_2O/g N) 125 ml of water less per day than the MRE group.

Sodium intake of the RCW group was also reduced by virtue of the level of salt in this ration. The RCW group consumed approximately 8.8 g of NaCl/day while the MRE group consumed 12.1 g NaCl/day. A theoretical calculation can be made of water saved due to a reduced kidney solute load. A reduction of intake of 3.3 g of NaCl/day could be predicted to reduce the water burden by 300-500 ml/day according to the prediction graph of Baker et al (20). The combination of reduced sodium and reduced protein theoretically lowered the water requirement for the RCW group by 400-600 ml/man/day. Estimates of water consumption during this study compiled by Engell et al (21) indicated that both groups consumed similar quantities of water (approximately 3 L/man/day including food source water). Theoretically, at least, the RCW ration placed less of a water burden on the soldier although the RCW group did need to secure greater quantities (approximately 260 ml) of water to make up for the differences in moisture content of the rations. The net effect of the RCW would be to reduce canteen water requirements (for drinking and ration hydration) by 150-350 ml/day compared to the MRE.

Carbohydrate intakes for both groups were less than that recommended for glycogen repletion during prolonged aerobic endurance exercise (22). The RCW group did consume approximately 80 g of carbohydrate/man/day more than the MRE group. This is a significant amount of carbohydrates and might be considered a positive attribute of the RCW.

Fat intakes were lower for the RCW than the MRE group. Fat comprised 42% of the kcal in the MRE group and 32% of the kcal in the RCW group. The 32% figure is closer to nutritional health guidelines for dietary fat consumption (23). These differences are of relatively little significance over a 10 day time period but could be important over periods of extended use.

The lack of a complete nutrient profile for the RCW precludes assessment of the ability of the RCW to meet the MRDA for nutrients other than energy, protein, carbohydrate, fat and sodium in this report.

The blood chemistries showed greater change from pre to post measurements within ration groups than between rations groups. These changes were probably more related to the work done during the 10 day FTX and shifts in body fluid compartments than to the type of diet fed. In general, the changes noted were not serious or detrimental consequences of the diet and all values (with the exception of some pre-FTX BUN values) fell within normal ranges. Blood glucose was normal and not significantly different between ration groups after 10 days of consuming these rations. Blood triglycerides and cholesterol were reduced in both ration groups, probably due to a combination of physical activity and reduced fat intake. The changes in concentration of blood electrolytes are difficult to evaluate without quantitative data on changes in plasma volume pre to post FTX and differences in plasma volume due to dehydration between ration groups post FTX.

Hydration Status

The only data available on change in plasma volume are the calculated values based on anthropometrical data. These do little to help explain minor variations in blood electrolytes. The minor variations are probably normal perturbances in a concentration that is maintained by enhancement or reduction in sodium excretion. Within the renal tubule, the retention of sodium is coupled with excretion of potassium. In this study, adrenal control (Aldosterone) of plasma concentrations of sodium and potassium appeared to work well. The elevated values of urine specific gravity in the post test indicate that some degree of dehydration had occurred. The reasons for this include the availability of water to this group, the inadequacy of thirst in a cold environment (4), and the dehydrated nature of the ration. The time spent in the lock-down could be used to hydrate the soldiers before going to the field, which might result in more calories being consumed. Overall, the water discipline was not good, and less dehydration and perhaps greater food intakes could be encouraged if soldiers were instructed and expected to force fluids up to the levels of 4 liters per day or more.

The minor increases in the heart rate and blood pressures upon returning to camp were probably the result of higher levels of excitement (elevated catacholamines) due to ending of the study. We would have expected a somewhat greater change in arterial pressure if the weather had been colder. If pressures are to be measured, then they must be followed more closely in the field and upon returning from the field.

Food Item Selection and Consumption

The data collected on MRE component preferences for field rations carried in rucksacks revealed that entrees, starches, spreads, desserts, and fruits were all chosen at similar frequencies to take on the FTX. Caution is warranted in considering selection rates. These rates are not directly comparable except for food items that had equal opportunities for selection i.e., all entrees occurred in the rations in the same numerical density but coffee occurred more frequently than cocoa. Nevertheless, this data seems to say that all food item components of the MRE were not valued equally by the soldiers and those that were selected to be taken were not necessarily consumed in proportion to their availability.

Food item consumption rates for the RCW indicated that certain components such as the fruit soup and orange beverage bar were not consumed as well as other items such as the entrees or oatmeal. Considerations of the RCW food item consumption rates indicates that caloric intakes might be increased by decreasing or omitting certain food items with low consumption rates and increasing other more acceptable food items. Entrees were popular and highly consumed, but they account for only 558 calories of the total 4541 calories (appendix 1). Another entree could be added in place of some of the bar/cookie components which account for 2191 calories. The chocolate toffee bar was not very popular whereas the entrees were. Additional entrees could also be a possible replacement for the relatively unpopular fruit soup. An entree consumed rehydrated with hot water would accomplish many of the same purposes of the fruit soup (encourage fluid intake, provide a warming food/fluid, and provide extra calories). The orange beverage bar should be modified to increase palatibility or perhaps replaced with a more popular beverage such as cocoa or cider. Increasing the chicken noodle soup packets from 1 to 2 per day may result in greater fluid intake than that provided by the orange beverage bar. A more in-depth presentation of food item preferences and ration utilization and water use in this study can be found in the report by Engell et al (21).

Within the limitations of this test (lack of a complete nutrient profile for the RCW), it can be noted that the RCW supported 10 days of Special Forces cold weather training similar to the MRE ration. The failure of soldiers fed the MRE ration to consume enough of the ration to meet their energy needs and prevent weight loss has been noted in other tests of the MRE ration. The RCW did not prevent this weight loss and was similar to the MRE ration in this respect. Although the RCW contained less food water than the MRE, under the conditions of this test hydration status was similar for both groups and not indicative of severe dehydration. Under the conditions of this test, the RCW was not consumed in quantities sufficient to satisfy energy requirements and maintain body weights over a 10 day period of moderate to heavy work in a moderately cold environment.

SUMMARY AND CONCLUSIONS

A nutritional evaluation of the Meal, Ready-to-Eat (MRE) and a prototype Ration Cold Weather (RCW) for cold weather feeding was conducted with 10th Special Forces Group soldiers engaged in a 10 day Winter Warfare Field Training Exercise (FTX) at the White Moutain National Forest, NH during February, 1986.

The energy demands of soldiers performing heavy work in snow covered terrain may approach 4500 kcal/day. The test (RCW) group was issued and carried a 10 day supply of the entirely dehydrated RCW (4541 kcal/man/day). The control (MRE) group was issued only a 5 day supply of rations due to the greater bulk of 4 MRE meals per day (4892 kcal/day). This group was resupplied on the 5th day. The MRE group was permitted to break down the packaged meals and self selected to carry only approximately 3400 kcal/man/day to the field. The RCW group was not allowed to break down the ration due to its unfamiliarity. Body weight, body composition, hydration status, nutritional status, muscle strength, and muscle endurance were measured before and at the end of the study. Food and water intakes and urine specific gravity were estimated daily by self report in log books.

Despite large differences in the amount of calories the RCW (4541 kcal/man/day) and MRE (3400 kcal/man/day) groups carried with them, the reported average daily energy intakes of the RCW (2751 $\pm$ 70 kcal) and MRE 2733 $\pm$ 65 kcal) groups did not differ. Their energy intakes were approximately 1000-1200 kcal/day below their estimated energy expenditures (3950 kcal/day) and this energy deficit certainly contributed to the relatively large body weight losses (6.9 $\pm$ 0.6 vs. 5.7 $\pm$ 0.9 lbs for MRE and RCW, respectively) observed during the 10 day FTX. Caloric intakes were lowest on day 1 for both groups, rose on day 2 and remained stable thereafter. Body composition analysis suggest that approximately 50% of the weight loss was fat. The urinary specific gravity data suggest that both groups were not consuming enough water to maintain optimal hydration status under these field conditions and that a part of the body weight loss was due to hypohydration. Isokinetic muscle strength and endurance was maintained during the study despite the energy deficit and body weight loss.

To offset the increased water requirements of the RCW due to entirely dehydrated components, the RCW was specifically formulated to provide minimal but adequate amounts of protein and sodium. As consumed, the net effect of the RCW was calculated to reduce water requirements (for drinking and ration rehydration by 150-350 ml/day) compared to the MRE.

Although calorie intake of the RCW group did not differ, the RCW group consumed significantly more carbohydrate and less fat than the MRE group. This shift in macronutrient consumption with the RCW is thought to be favorable both in terms of maintaining muscle glycogen during prolonged and repeated aerobic endurance exercise and consistent with current nutritional health promotion guidelines. An evaluation of the adequency of vitamin and mineral (except sodium) intake from the RCW is not possible because the developer did not supply data on the actual vitamin and mineral composition of the RCW. Such data should be made available prior to future testing of this ration.

As noted previously, the RCW group consumed only 60 percent of the calories they carried with them. A review of the food item selection and consumption ratio data clearly indicates that certain items were consumed at very high rates (entrees, oatmeal cereals) and other items were consumed at very low rates (orange beverage bars, fruit soups, lemon tea and chocolate toffee bar) suggesting that future RCW menu modifications should consider offering two entrees instead of one entree per day, including more hot cereals and soups, less orange beverage powder and lemon tea, and eliminating certain desserts such as the chocolate toffee bar (appendix 1).

In conclusion, the RCW does offer logistical advantage (less weight, bulk), and avoids problems with freezing of items, and modestly reduces drinking water requirements (150-350 ml/man/day). However, the RCW did not effectively correct the problems noted with the MRE in this cold weather study and earlier studies in temperate climates of inadequate calorie consumption, body weight loss, and hypohydration.

RECOMMENDATIONS

1. The Ration Cold Weather (RCW) should retain its present caloric (4541 kcal), protein, and sodium composition.

2. A complete nutrient composition of the RCW including vitamin and minerals should be provided to ensure compliance with the Nutritional Standards for Operational Rations (AR 40-25).

3. Menu modifications should be made to improve the total consumption of the RCW. The present carbohydrate content could be maintained and a reduction in sugar content achieved by modifying or reducing the bar/cookie components and increasing entree size by adding carbohydrate entree extenders.

4. Items that encourage fluid consumption, i.e., chicken noodle soup, cocoa, and cider, should be increased and unpopular beverage items, should be reduced or replaced.

5. A problem common to all packaged rations is inadequate water consumption. Efforts toward better water discipline and forced drinking during cold weather operations should be implemented.

6. The results of this test of the RCW indicate that modifications and additional testing are necessary to establish that the RCW is superior to the MRE for cold weather operations.

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TABLES

Table 1. Nutrient Composition of the MRE and RCW Rations[1]

	Ration			
	MRE		RCW	
	per 4 MREs	per 1000 kcal	per 1 RCW	per 1000 kcal
Energy, kcal	4892	----	4541	
Protein, g	173	35	108	24
Carbohydrate, g	548	112	688	153
Fat, g	223	46	150	33
Sodium, mg	7188	1467	4508	1002
Water, g	524	107	42	9

[1] Nutrient composition to include vitamins and minerals was available for the MRE III ration but not the RCW.

Table 2. Isokinetic leg extension strength and endurance by diet group pre and post scenario

			PRE-SCENARIO			POST-SCENARIO		
Strength		n	$\bar{X}$	$\pm$	SEM	$\bar{X}$	$\pm$	SEM
30°/sec (Nm)	MRE	16	241.8	$\pm$	9.3	248.1	$\pm$	11.6
	RCW	18	227.6	$\pm$	4.1	224.2	$\pm$	6.2
180°/sec (Nm)	MRE	16	141.3	$\pm$	4.0	138.1	$\pm$	6.6
	RCW	18	128.1	$\pm$	4.1	128.6	$\pm$	3.7
Endurance								
Mean Peak Torque (Nm)	MRE	16	83.2	$\pm$	3.9	86.1	$\pm$	4.6
	RCW	15	76.2	$\pm$	2.8	80.3	$\pm$	2.6
MPT (Nm)/ Kg BW	MRE	16	1.06	$\pm$	0.04	1.14	$\pm$	0.05
	RCW	15	0.99	$\pm$	0.03	1.08	$\pm$	0.03
Highest Peak Torque (Nm)	MRE	16	133.5	$\pm$	6.4	134.4	$\pm$	6.3
	RCW	15	127.1	$\pm$	4.2	124.6	$\pm$	3.6
HPT (Nm)/ Kg BW	MRE	16	1.69	$\pm$	0.05	1.78	$\pm$	0.07
	RCW	15	1.65	$\pm$	0.04	1.67	$\pm$	0.05
Torque Decrease (%)	MRE	16	66.3	$\pm$	1.9	61.8	$\pm$	1.7
	RCW	15	69.7	$\pm$	3.3	61.3	$\pm$	1.2

Table 3. Isokinetic leg extension strength and endurance of current data vs. previous Army soldier samples

Source		n	30°/sec	180°/sec	MPT	MPT/kg	HPT	HPT/kg	DPT
1.Current Study	MRE	(16)	241.8	141.3	83.2	1.06	133.5	1.69	66.3
	RCW	(15)	227.6	128.1	76.2	0.99	127.1	1.65	69.7
2.Subject Pool (1)		(10)	208.4	132.1	82.8	1.07	129.5	1.67	62.7
3.Subject Pool (2)		(17)	----	139.9	86.2	1.11	141.2	1.82	67.0
4.Infantry	(3)	(48)	----	127.0	76.9	1.05	114.7	1.56	55.8
5.Subject Pool (4)			241.9	138.4	----	----	----	----	----
6.Infantry	(5)	34	----	----	78.0	1.07	119.6	1.65	63.9
Range Low			208	127	75	0.99	112	1.56	55.8
High			242	141	86	1.11	141	1.82	69.7

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Table 4. Hematocrit values for both ration groups pre and post scenario.

MRE			RCW		
SUBJECT ID	PRE TEST (%)	POST TEST (%)	SUBJECT ID	PRE TEST (%)	POST TEST (%)
60	46.0	46.0	80	46.0	43.5
62	45.0	43.5	81	47.0	43.5
63	42.5	48.5	82	43.0	42.5
65	47.0	48.5	83	46.0	44.0
66	47.0	50.8	84	45.0	44.5
67	46.5	48.5	85	44.5	43.0
68	49.0	47.5	86	44.0	44.0
70	42.5	44.0	87	45.0	43.5
71	40.5	43.5	88	49.0	47.0
72	43.5	47.0	89	44.0	43.5
73	46.0	44.0	90	44.0	43.5
74	47.5	46.0	91	47.5	51.5
76	47.0	47.0	92	46.0	44.5
77	39.5	42.5	93	45.5	44.0
78	48.5	51.0	95	38.5	41.5
79	47.0	44.0	96	44.0	44.5
			97	46.0	46.5
$\bar{X}$	45.3	46.4	$\bar{X}$	45.0	44.4
± SEM	±0.7	±0.7	± SEM	±0.5	±0.5

Table 5. Serum aldosterone concentrations for both ration groups pre and post scenario.

MRE			RCW		
SUBJECT ID	PRE TEST (ng/dl)	POST TEST (ng/dl)	SUBJECT ID	PRE TEST (ng/dl)	POST TEST (ng/dl)
60	9.26	35.66	80	19.67	20.25
62	29.60	12.46	81	18.56	9.12
63	13.54	33.69	82	17.10	19.28
65	26.53	31.09	83	23.37	18.97
66	13.75	17.20	84	16.13	13.51
67	8.71	25.32	85	30.34	19.57
68	27.18	27.69	86	21.24	32.07
70	18.97	12.18	87	15.51	19.43
71	15.52	30.05	88	19.56	14.40
72	15.09	14.53	89	17.31	65.78
73	16.12	8.51	90	17.34	17.90
74	6.62	16.80	91	25.01	27.30
76	11.04	14.99	92	18.65	25.53
77	13.86	11.73	93	19.56	18.45
78	46.75	32.93	94	13.66	12.48
79	11.91	12.11	95	13.56	15.25
			96	10.14	17.43
			97	15.67	17.30
$\bar{X}$	17.78	21.06	$\bar{X}$	18.47	21.33
$\pm$ SEM	$\pm$2.56	$\pm$2.37	$\pm$ SEM	$\pm$1.09	$\pm$2.91

Table 6. Serum osmolality for both ration groups pre and post scenario

MRE			RCW		
SUBJECT ID	PRE TEST (mmol/kg)	POST TEST (mmol/kg)	SUBJECT ID	PRE TEST (mmol/kg)	POST TEST (mmol/kg)
60	284.0	284.0	80	289.0	267.0
62	290.0	286.0	81	284.0	291.0
63	294.0	270.0	82	286.0	301.0
65	294.0	284.0	83	299.0	287.0
66	292.0	282.0	84	282.0	287.0
67	294.0	280.0	85	295.0	284.0
68	293.0	282.0	86	289.0	281.0
70	290.0	282.0	88	286.0	284.0
71	290.0	282.0	88	286.0	284.0
72	294.0	283.0	89	292.0	280.0
73	289.0	283.0	90	287.0	282.0
74	286.0	276.0	91	288.0	297.0
76	292.0	285.0	92	298.0	295.0
77	298.0	286.0	93	288.0	294.0
78	292.0	288.0	94	302.0	308.0
79	302.0	302.0	95	295.0	288.0
			96	296.0	295.0
			97.	281.0	286.0
$\bar{X}$	292.0	283.0	$\bar{X}$	290.0	288.0
$\pm$ SEM	$\pm$1.0	$\pm$2.0	$\pm$ SEM	$\pm$1.0	$\pm$2.0

Table 7. Calculated values for blood volume, plasma volume, and total body water for MRE group.

Subject ID	BV_{pre}--L	PV_{pre}--ml	$\%\Delta PV_{post}$	TBW_{pre}--L	TBW_{post}--L
60	5.58	3114	0	46.56	46.89
62	5.14	2919	5.9	43.08	44.17
63	5.14	3043	-21.0	42.84	43.92
65	5.53	3036	-5.7	47.04	47.87
66	5.77	3168	-13.7	50.16	50.87
67	5.55	3075	-8.6	46.50	48.35
68	5.23	2772	5.8	44.64	45.43
70	5.70	3374	-5.6	49.86	48.48
71	6.18	3775	-11.4	51.0	51.18
72	6.06	3527	-12.6	55.08	55.47
73	5.61	3136	8.3	46.86	46.69
74	5.54	3014	5.9	47.46	47.12
76	4.83	2652	0	40.26	40.83
77	6.33	3931	-11.5	56.82	56.62
78	4.85	2590	-8.8	37.92	38.05
79	5.50	3019	12.6	46.86	47.85
$\bar{X} \pm$ SEM	5.53 $\pm$ 0.10	3134 $\pm$ 92.0		47.06 $\pm$ 1.23	47.48 $\pm$ 1.18

Table 8. Calculated values for blood volume, plasma volume, and total body water for the RCW group.

Subject ID	BV_{pre}--L	PV_{pre}--ml	$\% \Delta PV_{post}$	TBW_{pre}--L	TBW_{post}--L
80	5.76	3214	10.29	46.26	46.42
81	5.68	3118	14.38	53.88	53.31
82	4.75	2788	2.09	40.62	41.06
83	5.57	3108	8.49	47.94	48.62
84	5.09	2891	2.06	43.14	43.76
85	4.99	2859	5.92	38.04	38.99
86	5.94	3433	0	51.30	52.03
87	5.04	2862	5.9	41.28	42.32
88	5.48	2904	7.95	45.48	45.64
89	6.05	3496	1.66	52.56	53.69
90	5.56	3213	1.66	45.96	45.96
91	5.21	2375	-14.14	43.56	44.03
92	6.05	3375	6.30	51.96	53.26
93	4.71	2651	6.31	37.08	37.08
94				39.30	39.30
95	6.20	3912	-11.55	56.76	55.78
96	5.56	3213	-2.03	43.56	43.87
97	5.20	2901	-1.61	43.38	42.92
$\bar{X} \pm$ SEM	5.46 $\pm$ 0.11	3077 $\pm$ 88.0		45.67 $\pm$ 1.34	46.00 $\pm$ 1.33

Table 9. Mean heart rate and blood pressure values for MRE group.

			Heart rate	Systolic BP	Diastolic BP
Standing	Pre	$\bar{X}$	79	126	76
		$\pm$ SEM	2	3	3
	Post	$\bar{X}$	89	134	85
		$\pm$ SEM	2	3	2
Sitting	Pre	$\bar{X}$	73	124	75
		$\pm$ SEM	2	3	2
	Post	$\bar{X}$	81	131	82
		SEM	2	4	2

Table 10. Mean heart rate and blood pressure values for RCW group.

			Heart Rate	Systolic BP	Diastolic BP
Standing	Pre	$\bar{X}$	82	129	73
		$\pm$ SEM	2	2	2
Sitting	Pre	$\bar{X}$	88	129	82
		$\pm$ SEM	2	2	2
Sitting	Pre	$\bar{X}$	75	128	74
		$\pm$ SEM	2	2	2
Standing	Post	$\bar{X}$	78	128	80
		$\pm$ SEM	2	2	2

FIGURES

FIGURE LEGENDS

1. Mean body weights pre and post FTX for MRE and RCW groups. Significant pre vs. post within group differences are denoted by a star above the bar. There were no significant differences in body weight loss between rations.

2. Mean percent body fat pre and post FTX for MRE and RCW groups. Significant pre vs. post within groups. Significant pre vs. post within group differences are denoted by a star above the bar. The MRE group lost significantly more body fat than the RCW group.

3. Daily caloric consumptions for both ration groups. Significance between ration comparisons by day are denoted by a star above the bar. The horizontal dotted lines represent the 9 day group means.

4. Daily protein consumption for both ration groups. Significance between ration comparisons by day are denoted by a star above the bar. The horizontal dotted lines represent the 9 day group means.

5. Daily carbohydrate consumption for both ration groups. Significance between ration comparisons by day are denoted by a star above the bar. The horizontal dotted lines represent the 9 day group means.

6. Daily fat consumption for both ration groups. Significance between ration comparisons by day are denoted by a star above the bar. The horizontal dotted lines represent the 9 day group means.

7. Mean consumption values for the nine day test for calories, protein, carbohydrates, and fat. The dotted lines for calories and protein represent the MRDA and the line for carbohydrates represents the NSOR. The MRDA for carbohydrates has not been established. There is also no MRDA for fat, however, an upper limit of 160 g/man/day is recommended in the NSOR. Significance between ration differences are denoted by a star above the bar.

8. Mean sodium consumption for the nine day test. The safe and adequate level of sodium recommended by the MRDA is 5500 mg/man/day or 1700 mg/1000 kcal of diet. The RDA lists a range of 100-3300 mg/man/day as a safe and adequate level. Significance between ration differences is denoted by a star above the bar.

9. Mean urinary ketones for both ration groups. The upper figure represents a 9 day mean for each group and the lower figure shows daily group means for the RME and RCW groups. These values were estimated by urine dipsticks which measure acetoacetone.

10-21. Mean blood chemistries pre and post FTX for MRE and RCW ration groups. Horizontal dotted lines represent normal ranges for these chemistries. Significant pre vs. post within group comparisons are denoted by a star above the bar. There were no significant differences between ration groups for pre measurements except for urea nitrogen. Calcium, protein, and globulin post measurements were significantly different between ration groups for post measurements.

22-28. Mean values for percentage of MRE food items taken vs. eaten. % taken represents the percent of each food item available in 9 days rations (36 MRE meals) that the soldiers selected to take to the field. % eaten represents the percent of the taken food items that were reported consumed.

29-34. Mean values for percentage of RCW food items that were eaten. % eaten represents the percent of 9 days rations (9 RCW rations) that the soldiers consumed. All RCW rations issued were taken to the field.

35. Mean values for urine specific gravity (TS meter) for both ration groups pre and post FTX.

36. Mean values for daily specific gravity (dipstick) for both ration groups.

37. Mean values for urinary sodium concentrations for both ration groups pre and post FTX. Pre vs. Post significant differences are denoted by a star above the bar. The MRE post values was significantly greater than the RCW post value.

38. Mean values for urinary potassium concentratoins for both ration groups pre and post FTX. Significant pre vs. post differences within ration groups are denoted by a star above the bar.

1986 Ration Cold Weather Test (10th Special Forces)

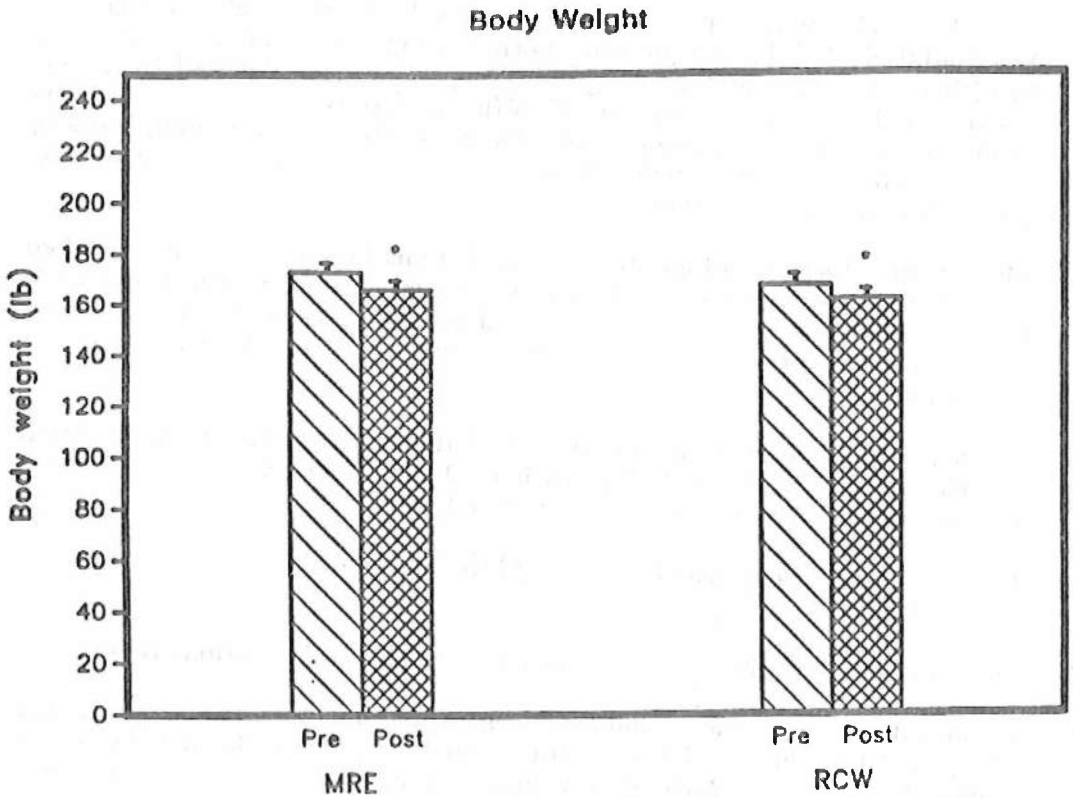


Figure 1

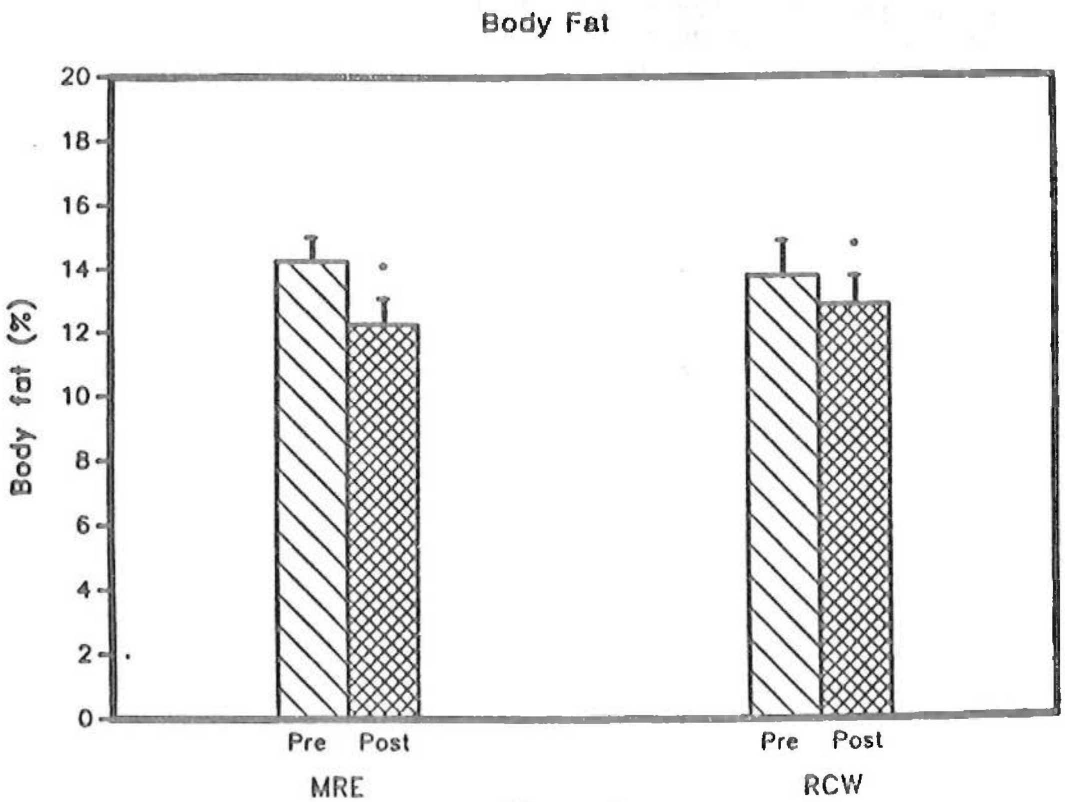
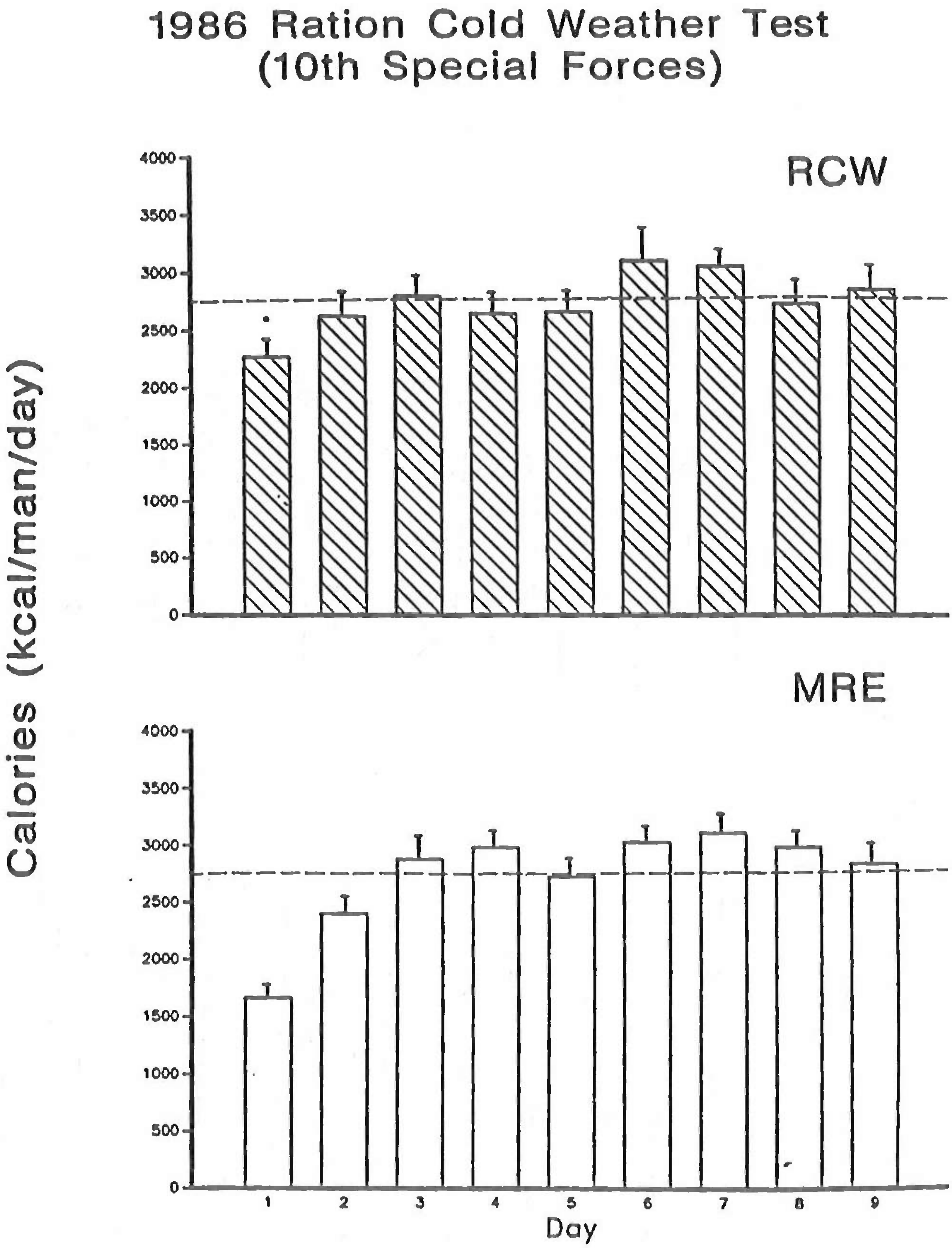


Figure 2



1986 Ration Cold Weather Test
(10th Special Forces)
RCW
MRE
Calories (kcal/man/day)
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
Day

Figure 3

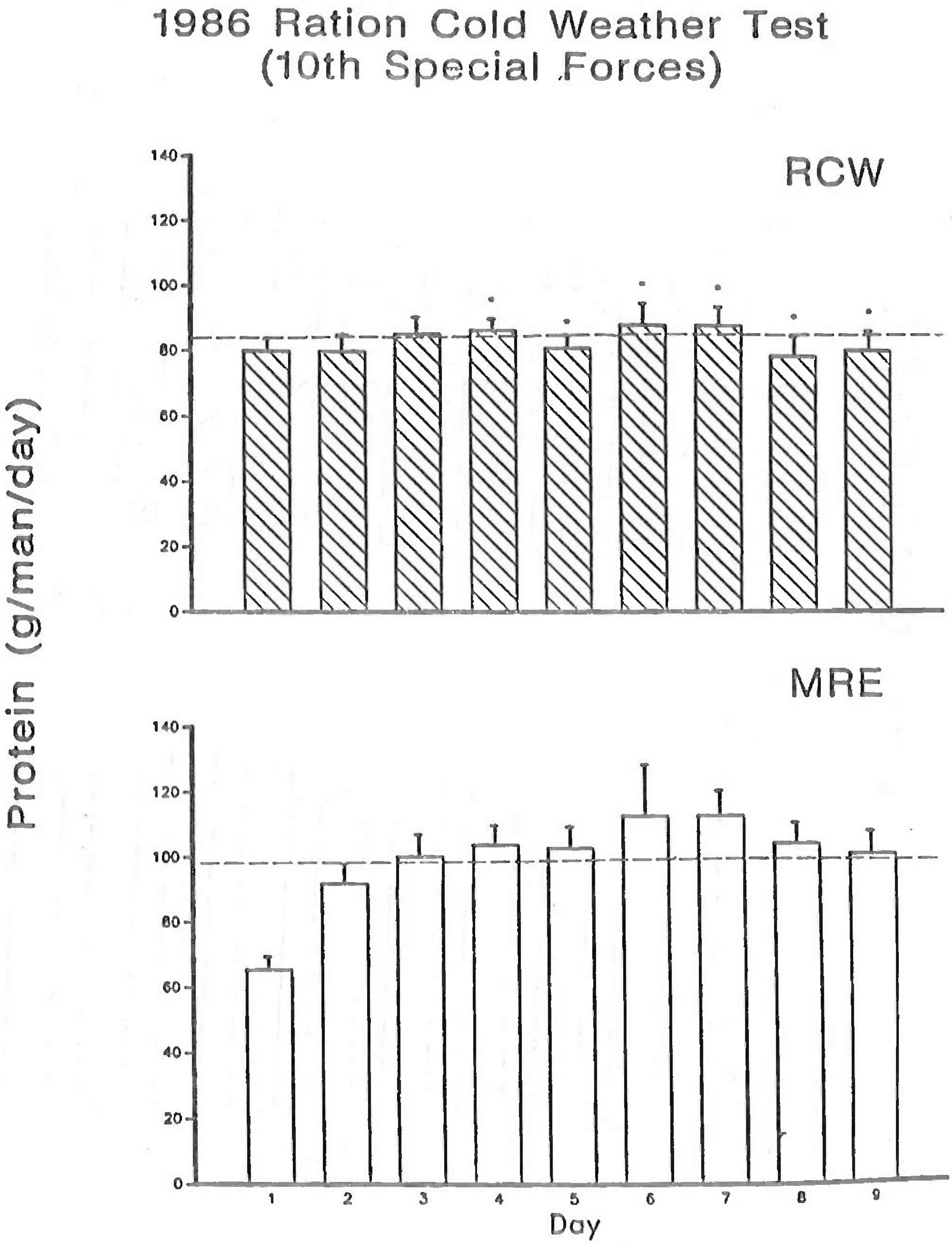

1986 Ration Cold Weather Test
(10th Special Forces)
RCW
MRE
Protein (g/man/day)
Day
0
20
40
60
80
100
120
140
1
2
3
4
5
6
7
8
9

Figure 4

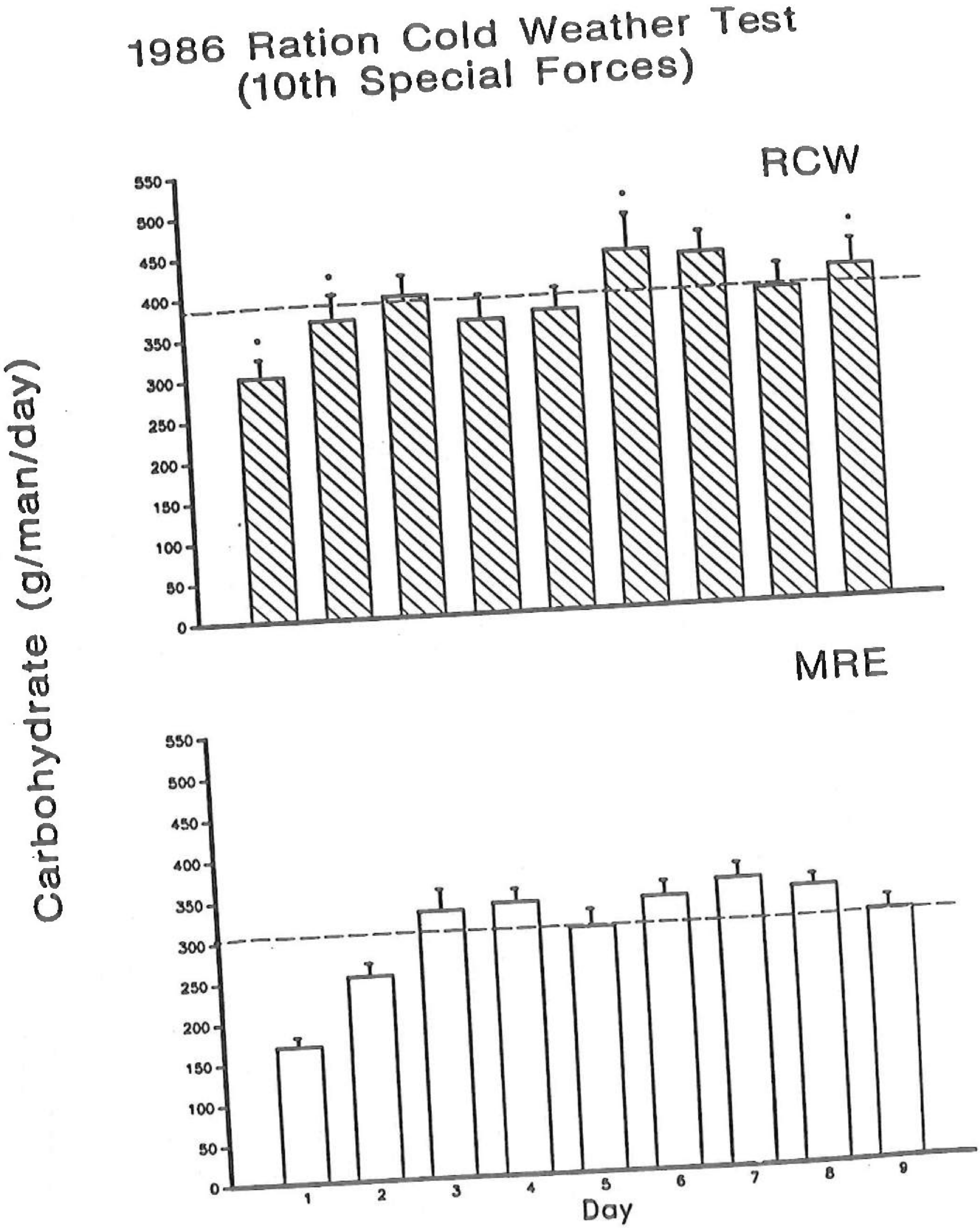

1986 Ration Cold Weather Test
(10th Special Forces)
RCW
MRE
Carbohydrate (g/man/day)
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
Day

Figure 5

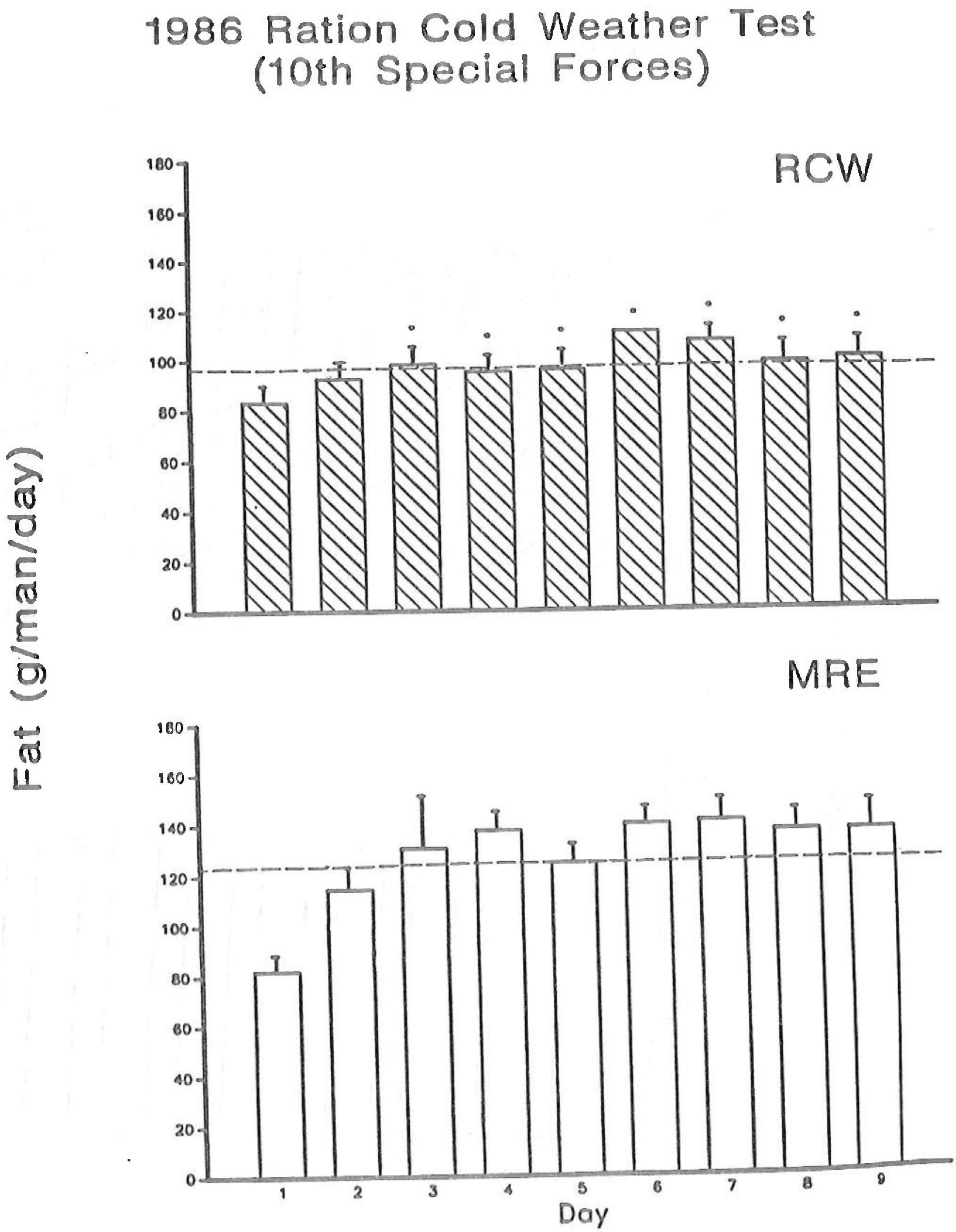

1986 Ration Cold Weather Test
(10th Special Forces)
RCW
MRE
Fat (g/man/day)
Day
0
20
40
60
80
100
120
140
160
180
1
2
3
4
5
6
7
8
9

Figure 6

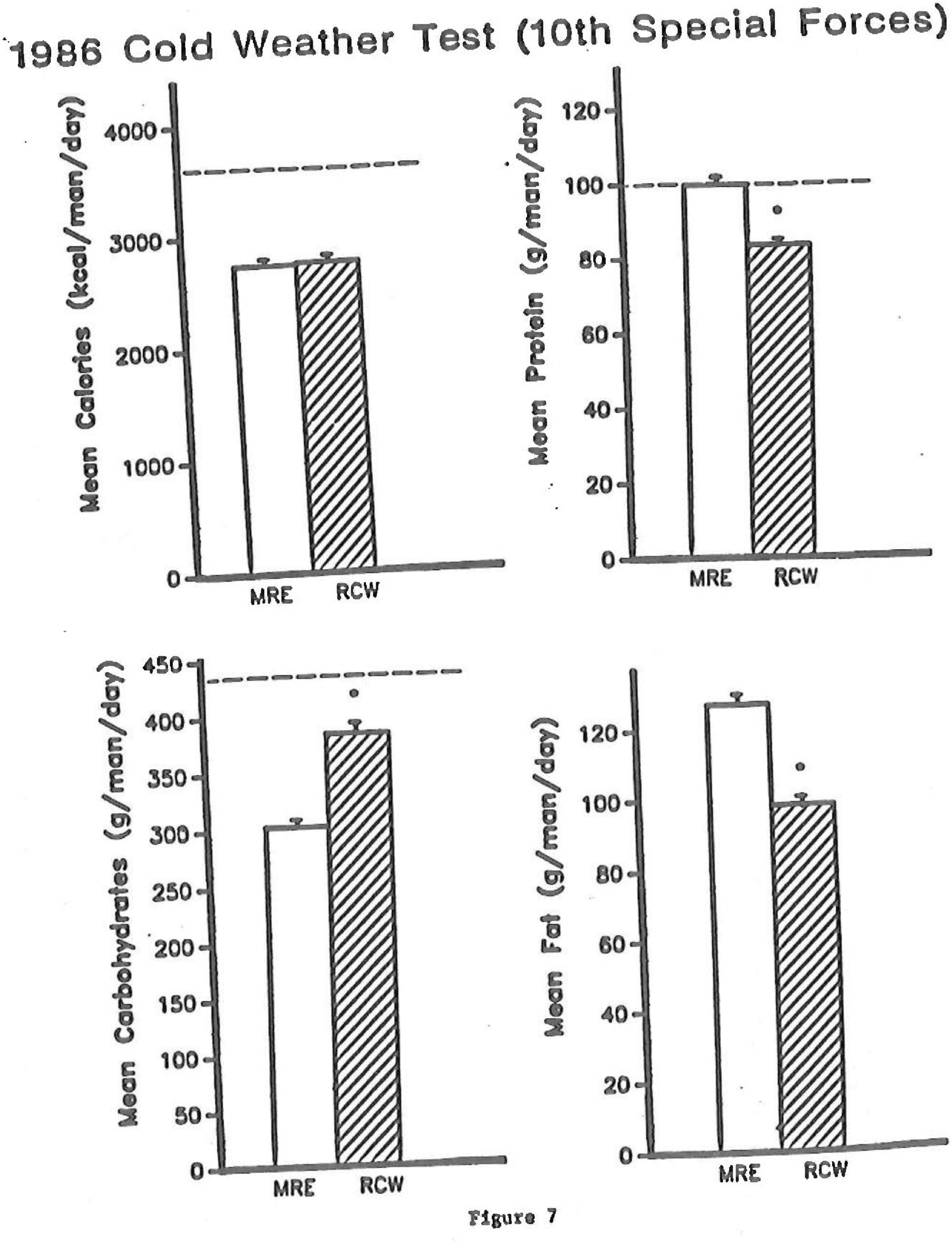

1986 Cold Weather Test (10th Special Forces)
Mean Calories (kcal/man/day)
4000
3000
2000
1000
0
MRE
RCW
Mean Protein (g/man/day)
120
100
80
60
40
20
0
MRE
RCW
Mean Carbohydrates (g/man/day)
450
400
350
300
250
200
150
100
50
0
MRE
RCW
Mean Fat (g/man/day)
120
100
80
60
40
20
0
MRE
RCW

Figure 7

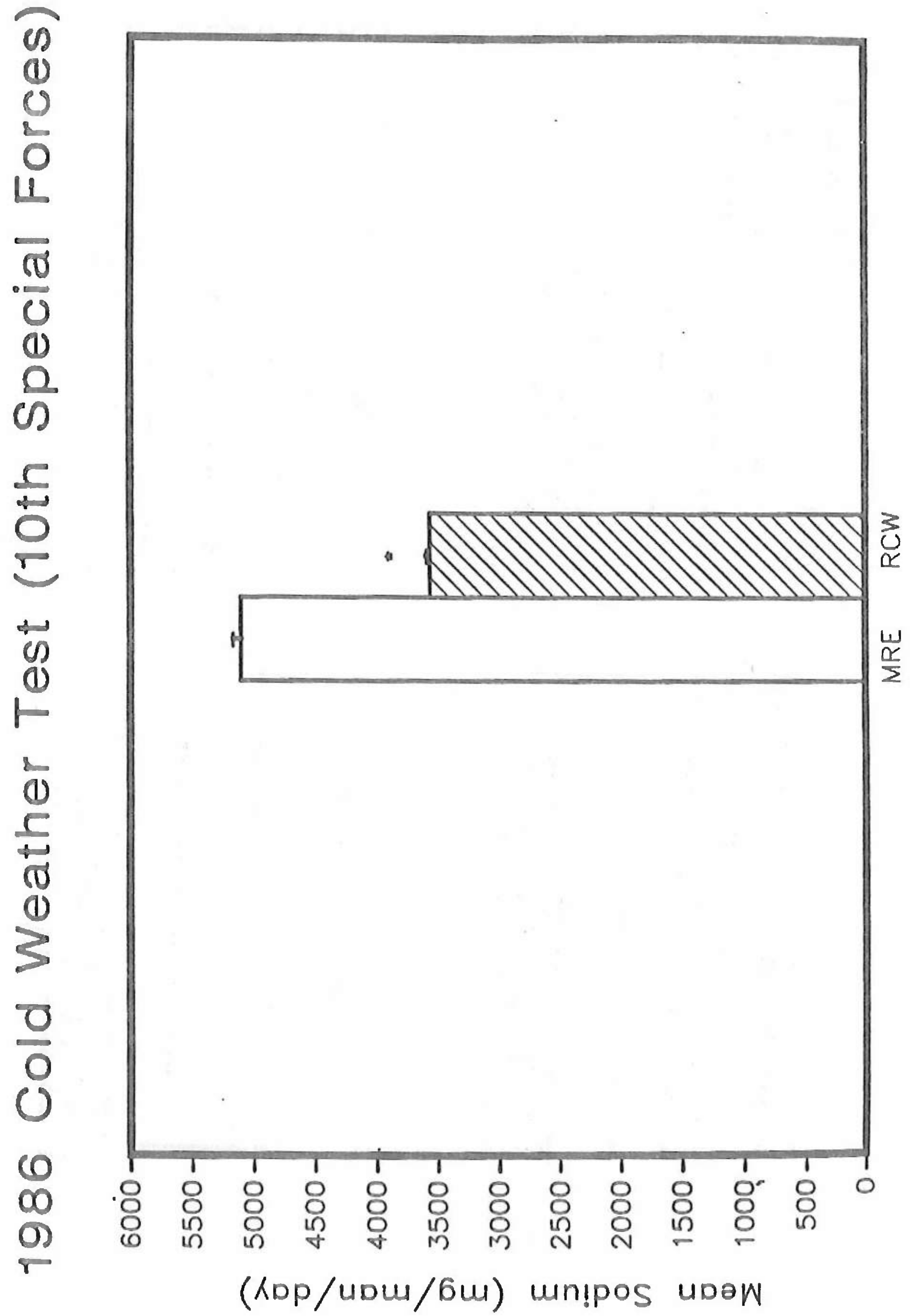
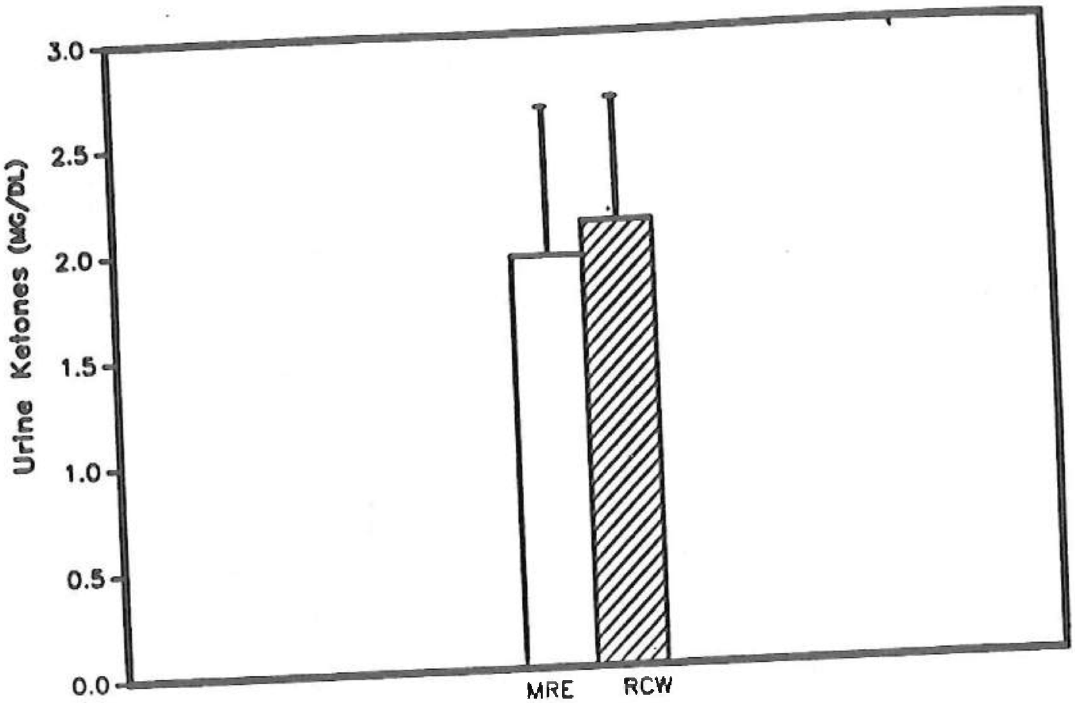

1986 Cold Weather Test (10th Special Forces)
Mean Sodium (mg/man/day)
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
MRE
RCW

Figure 8

1986 Cold Weather Test (10th Special Forces)



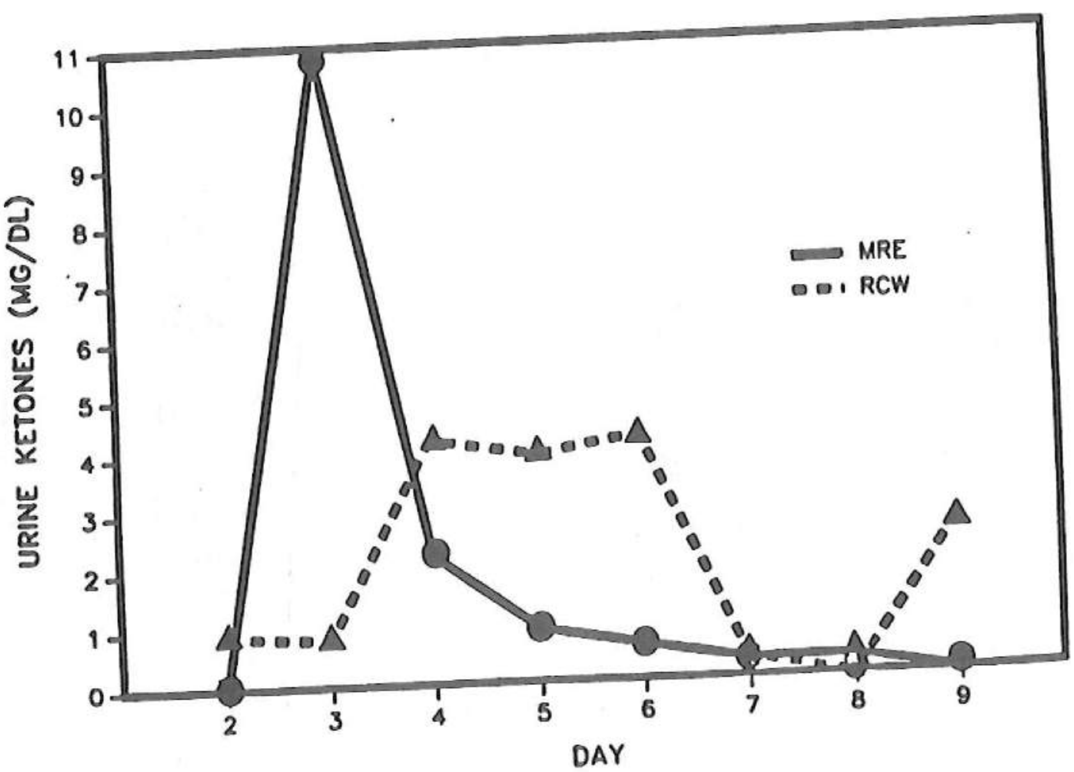


Figure 9

1986 Ration Cold Weather Test (10th Special Forces)

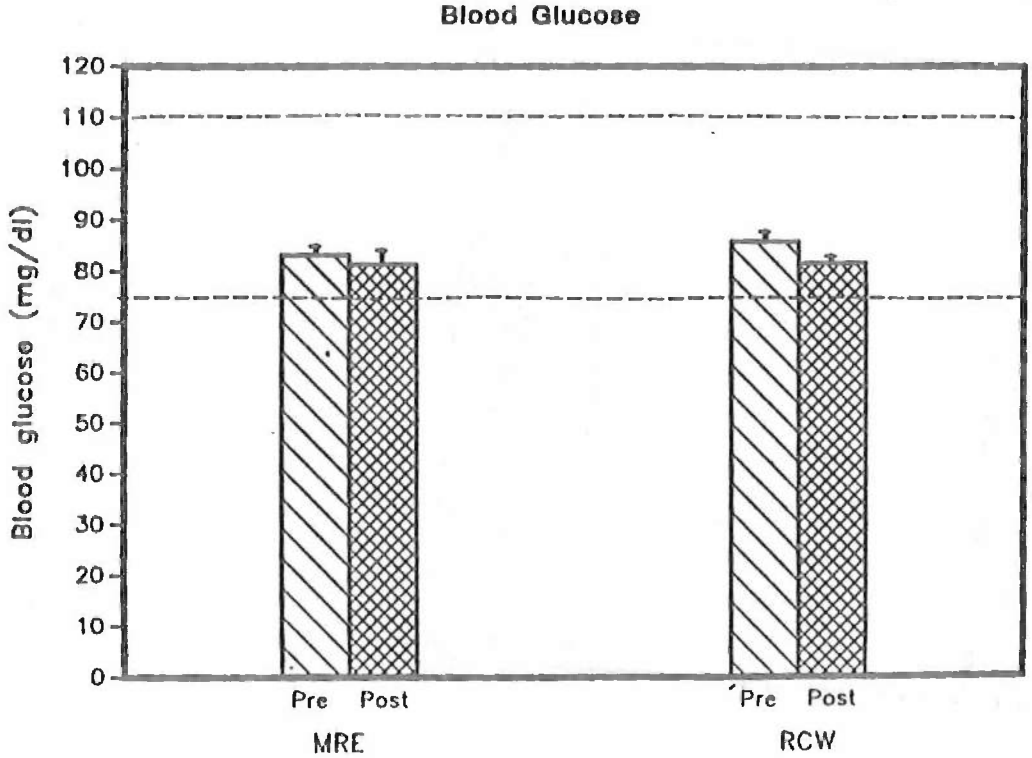


Figure 10

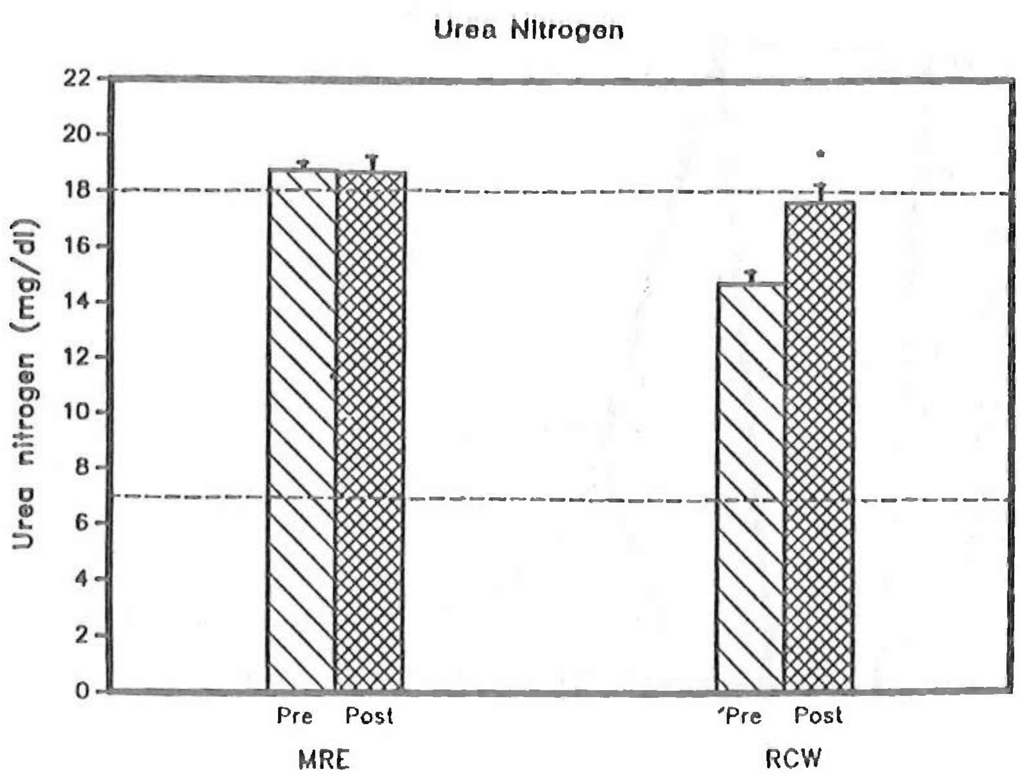


Figure 11

1986 Ration Cold Weather Test (10th Special Forces)

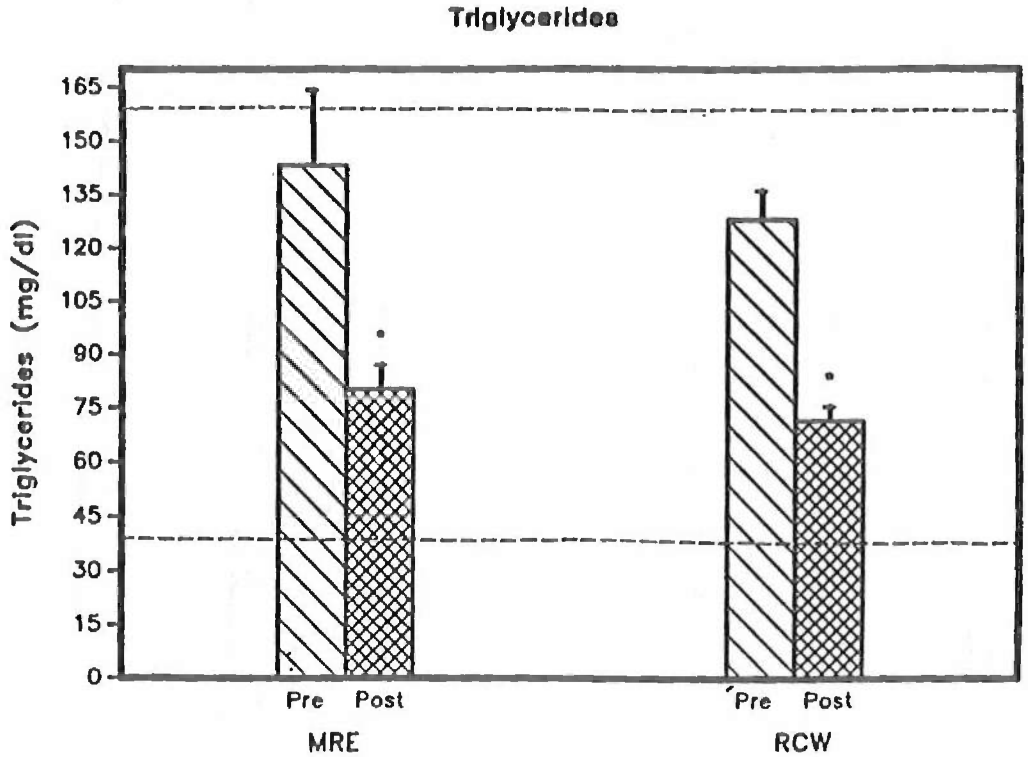


Figure 12

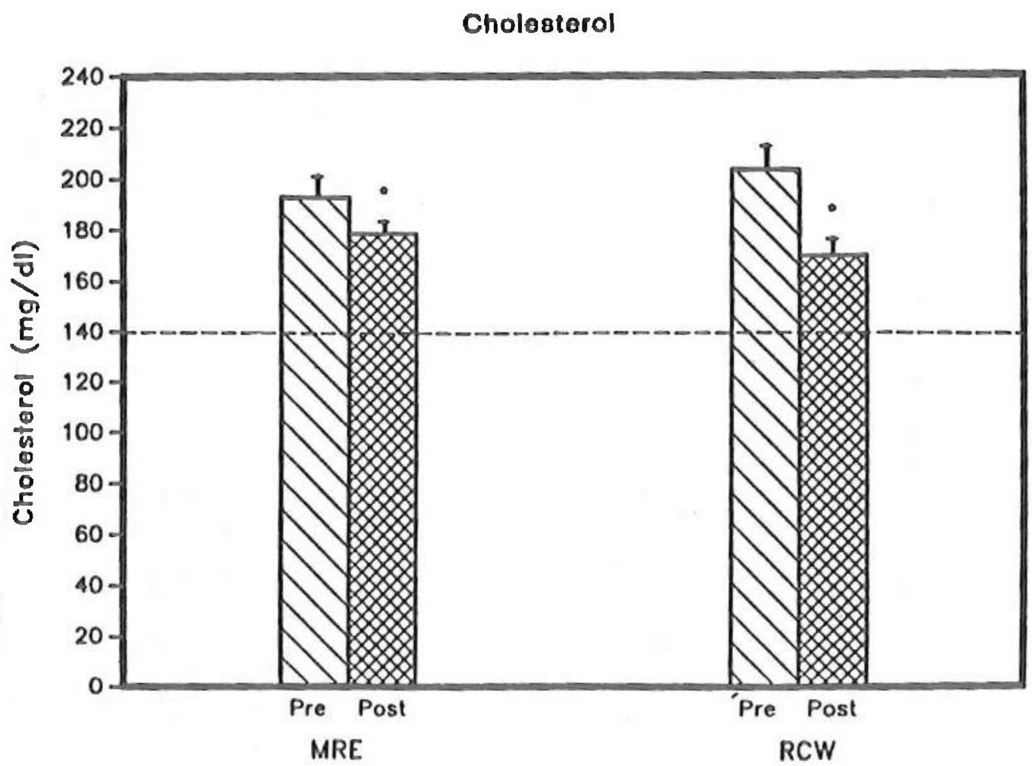


Figure 13

@ 2800 kcal/day

1986 Ration Cold Weather Test (10th Special Forces)

Sodium

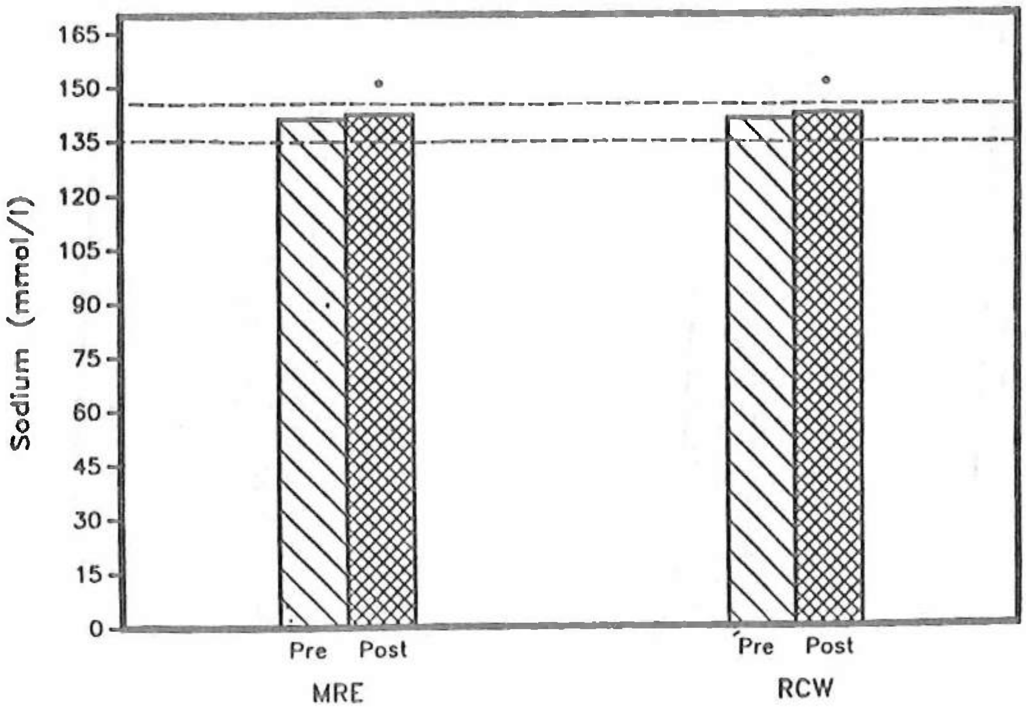


Figure 14

Potassium

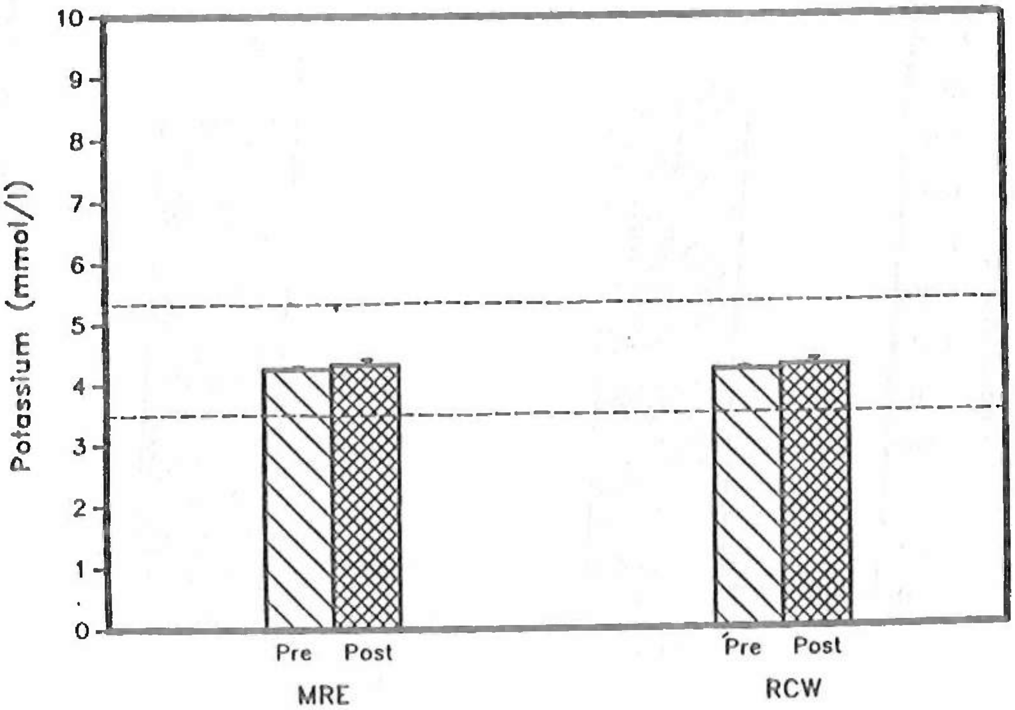


Figure 15

1986 Ration Cold Weather Test (10th Special Forces)

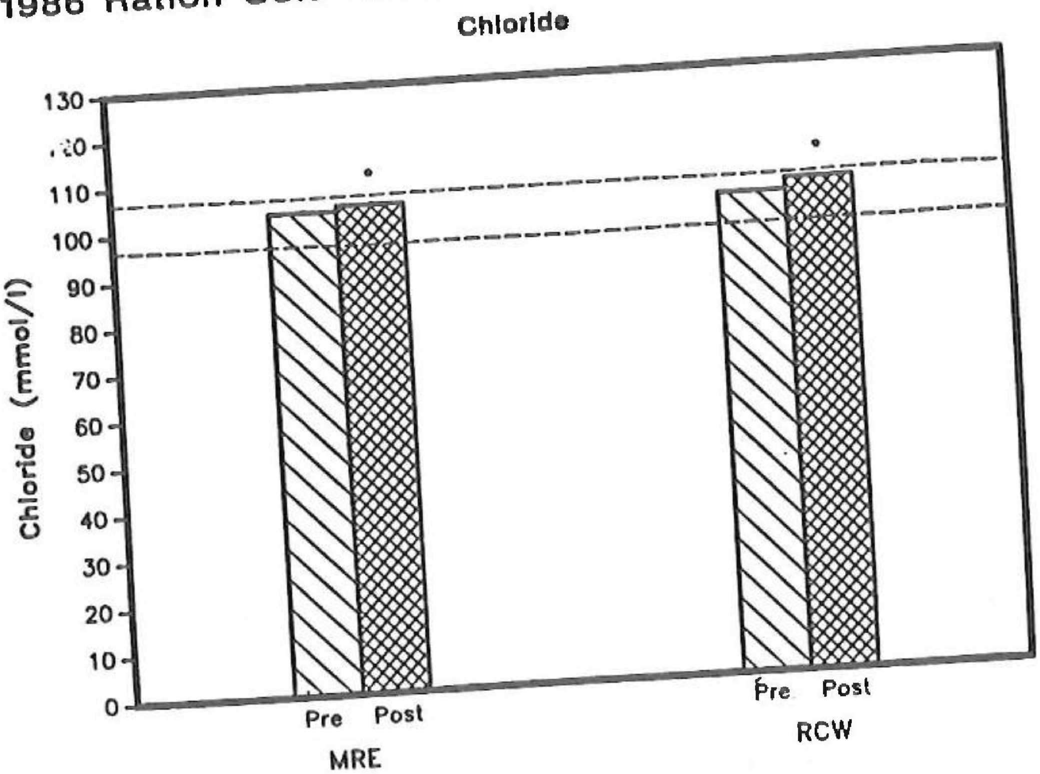


Figure 16

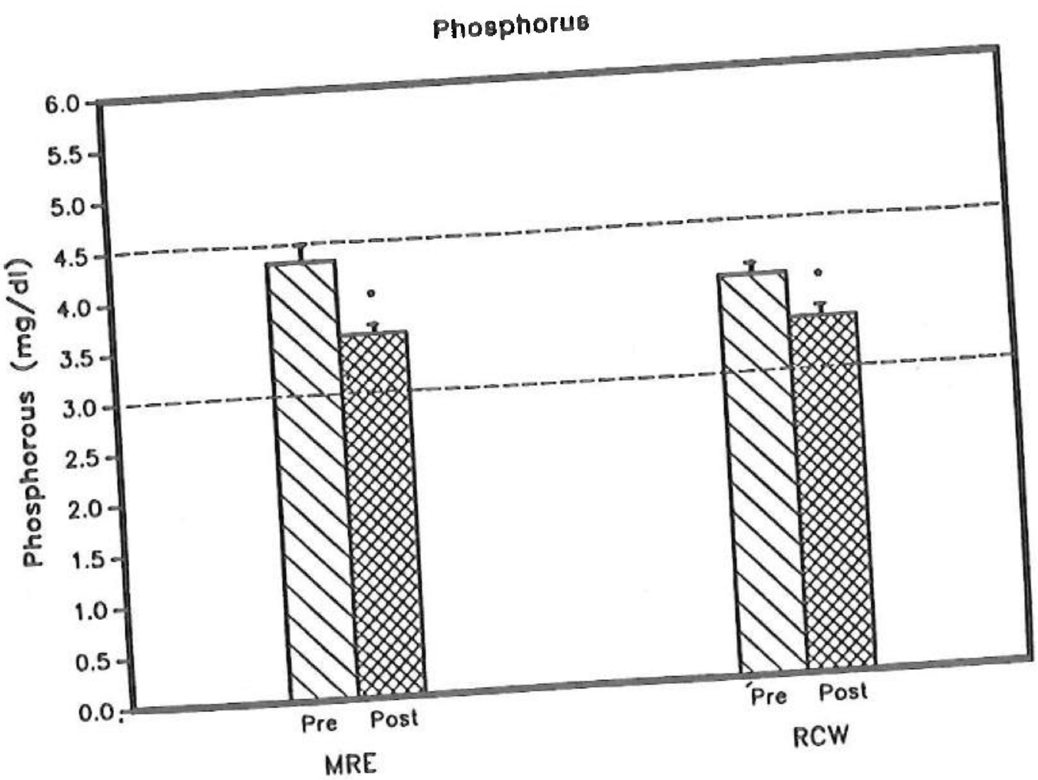


Figure 17

1986 Ration Cold Weather Test (10th Special Forces)

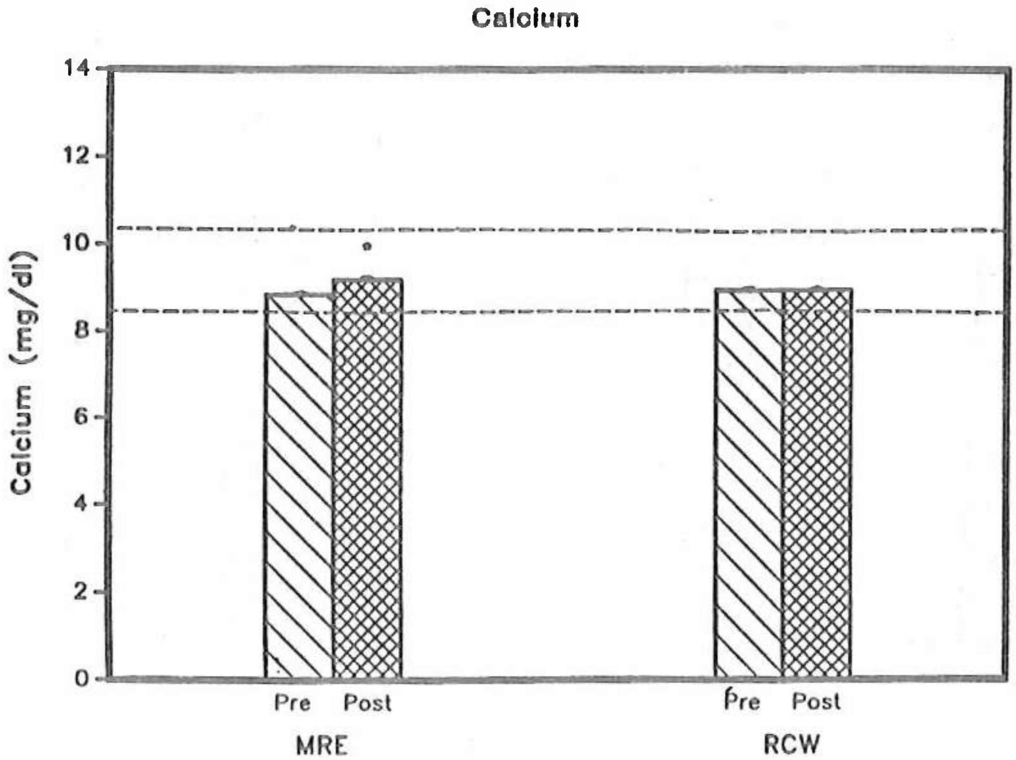


Figure 18

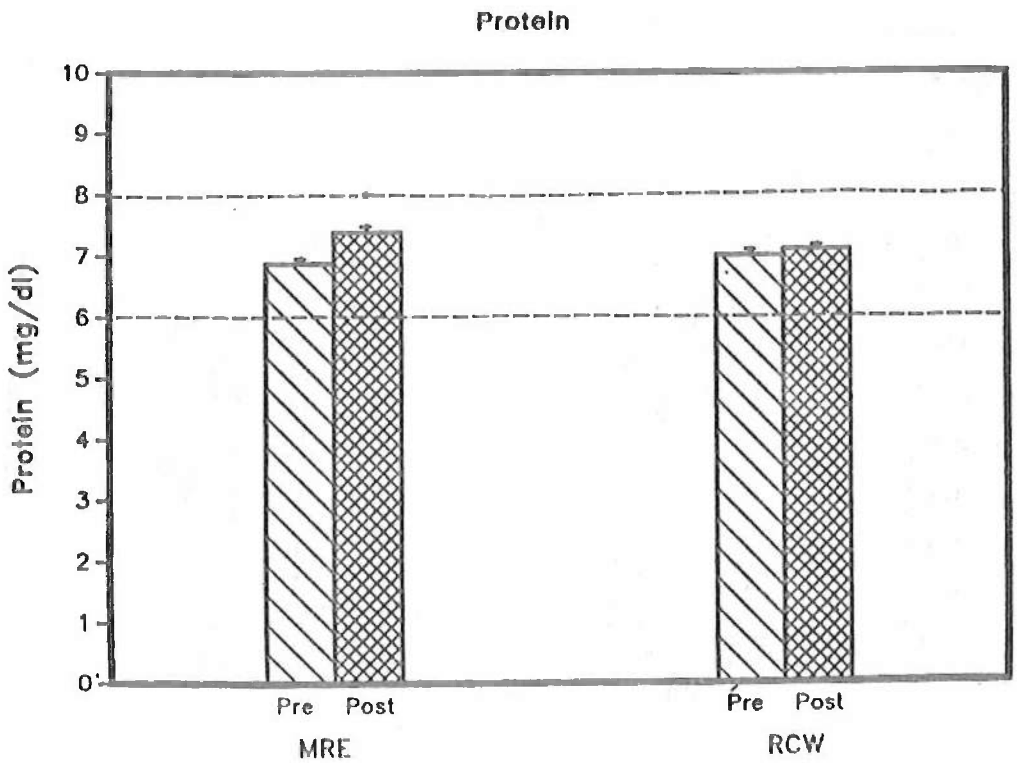


Figure 19

1986 Ration Cold Weather Test (10th Special Forces)

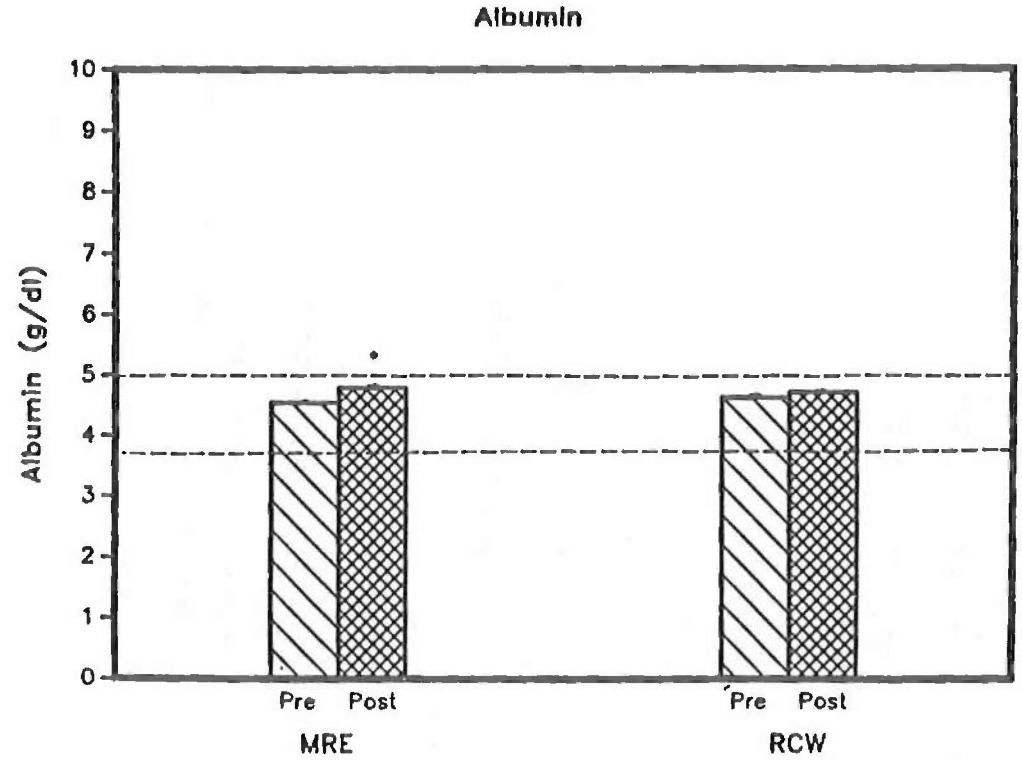


Figure 20

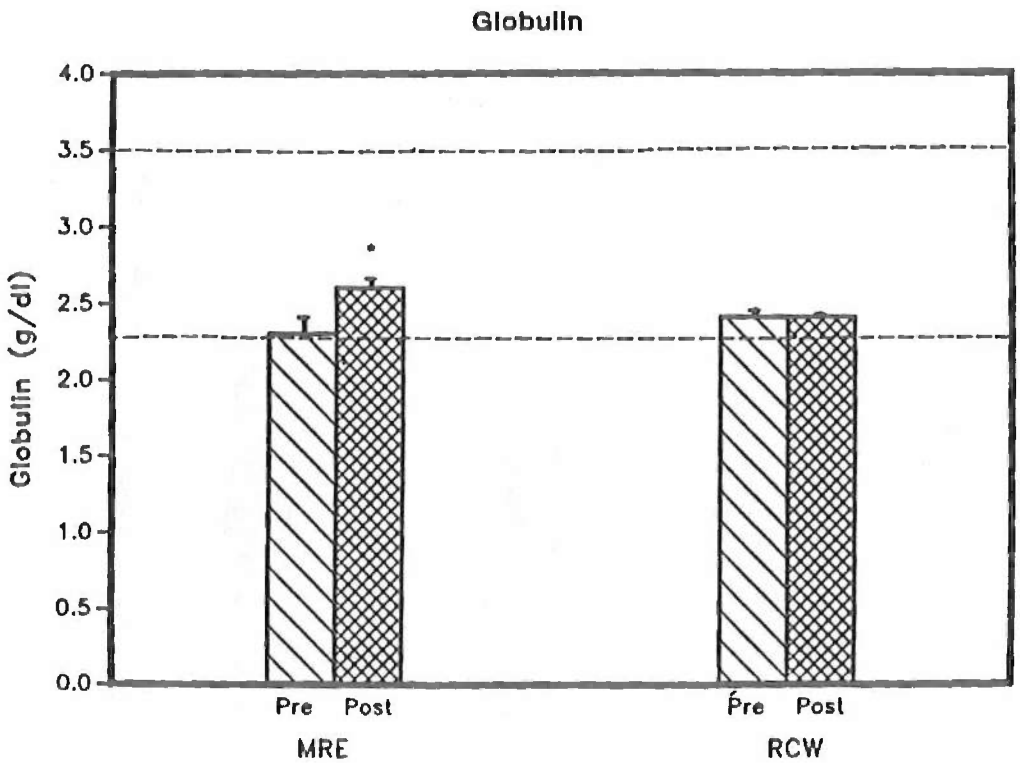


Figure 21

MRE-Entrees

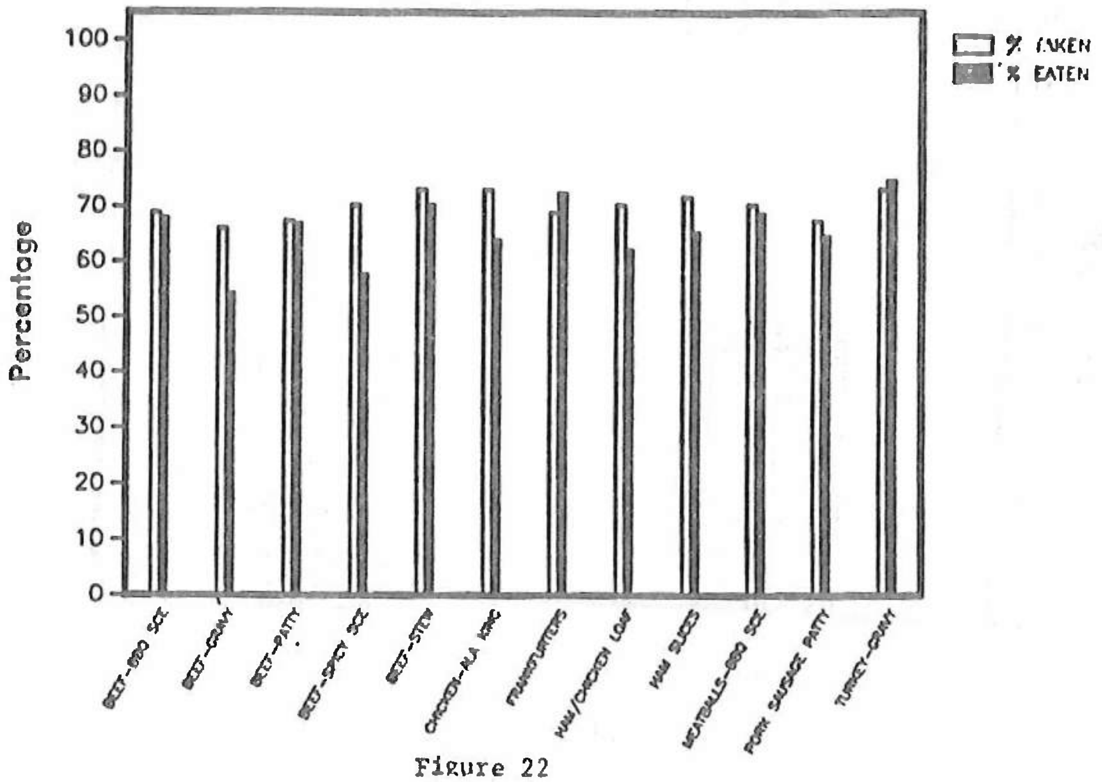


Figure 22

MRE-Starches

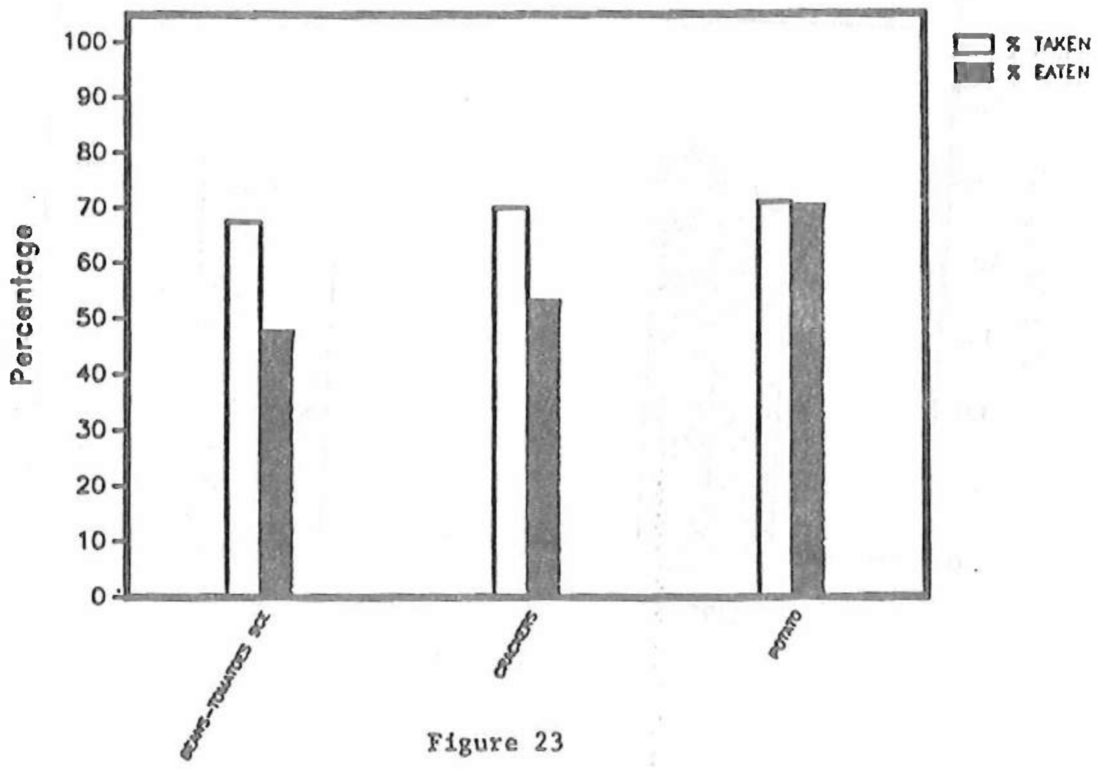


Figure 23

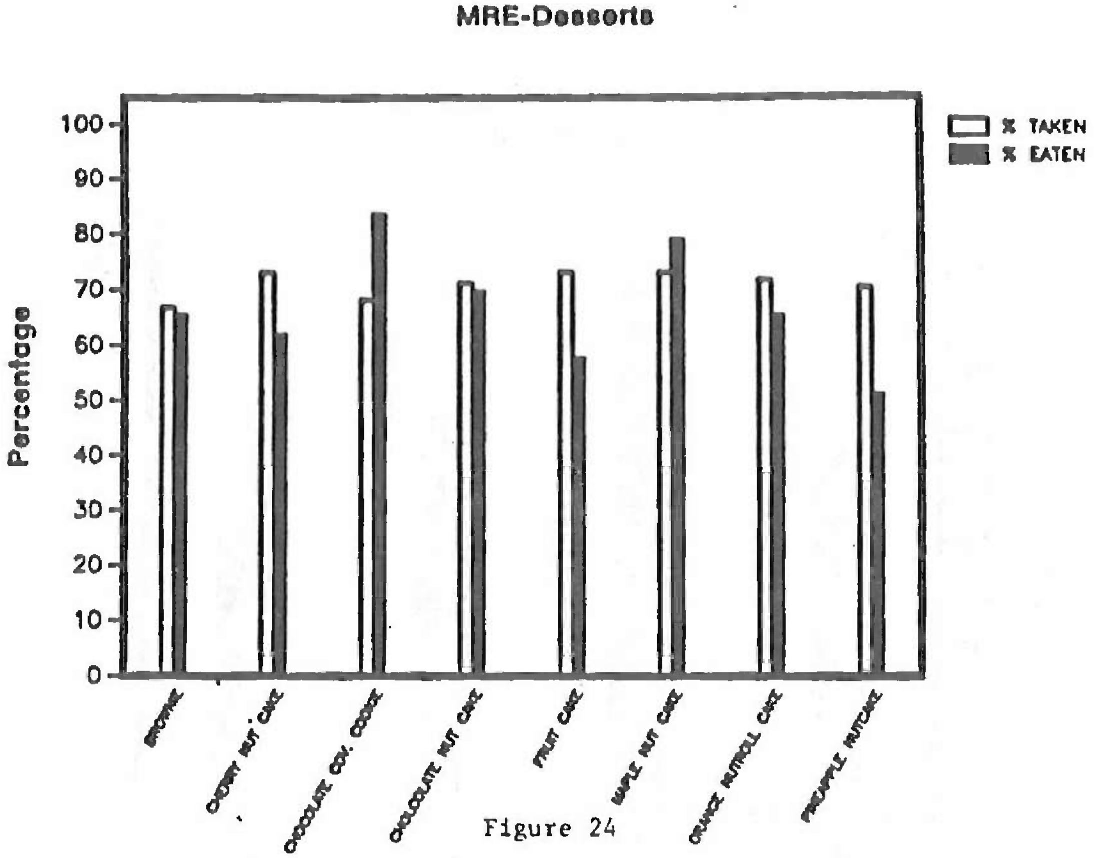


Figure 24

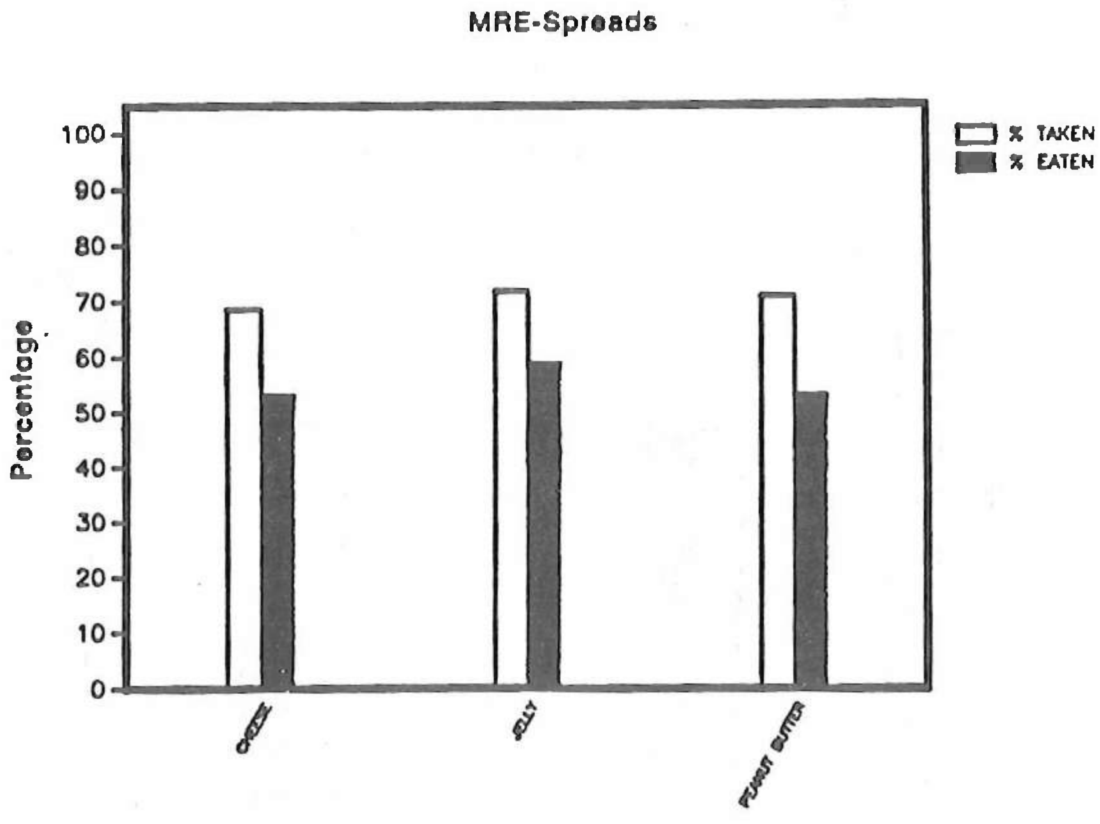


Figure 25

MRE-Dried Fruits

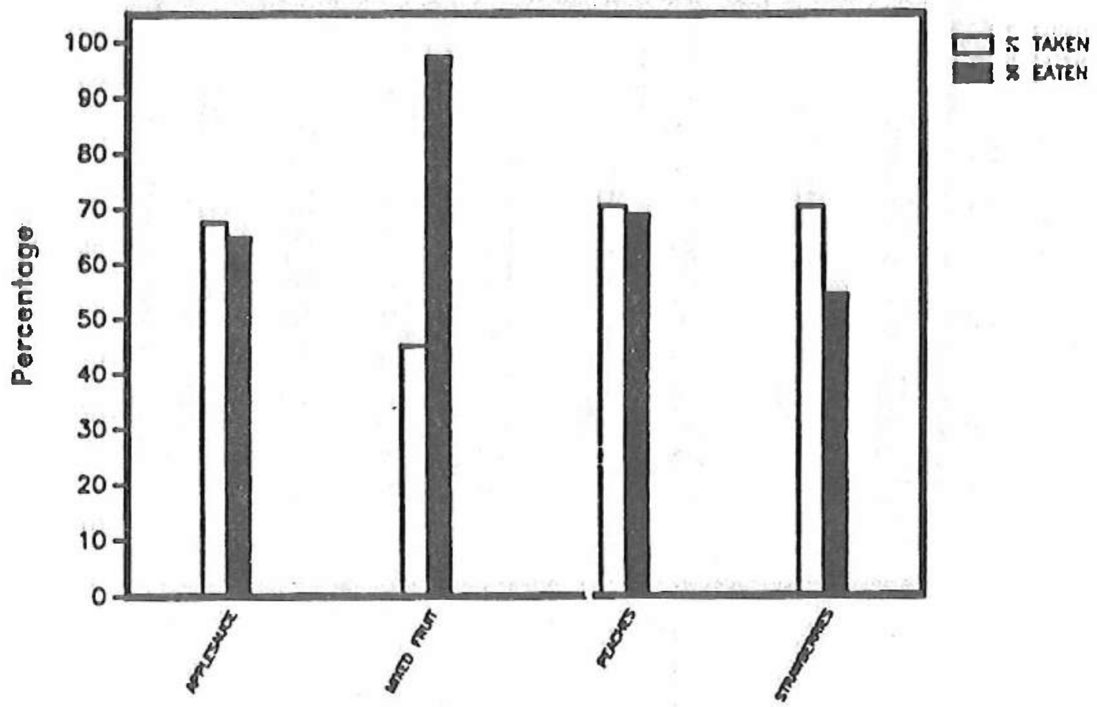


Figure 26

MRE-Beverages

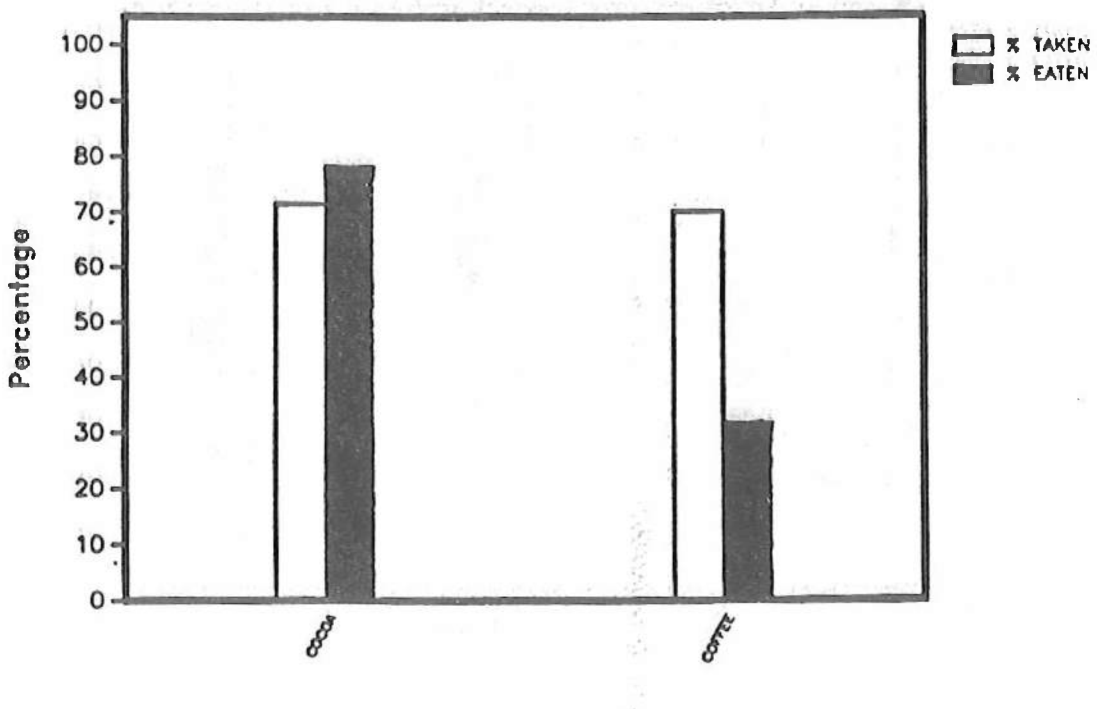


Figure 27

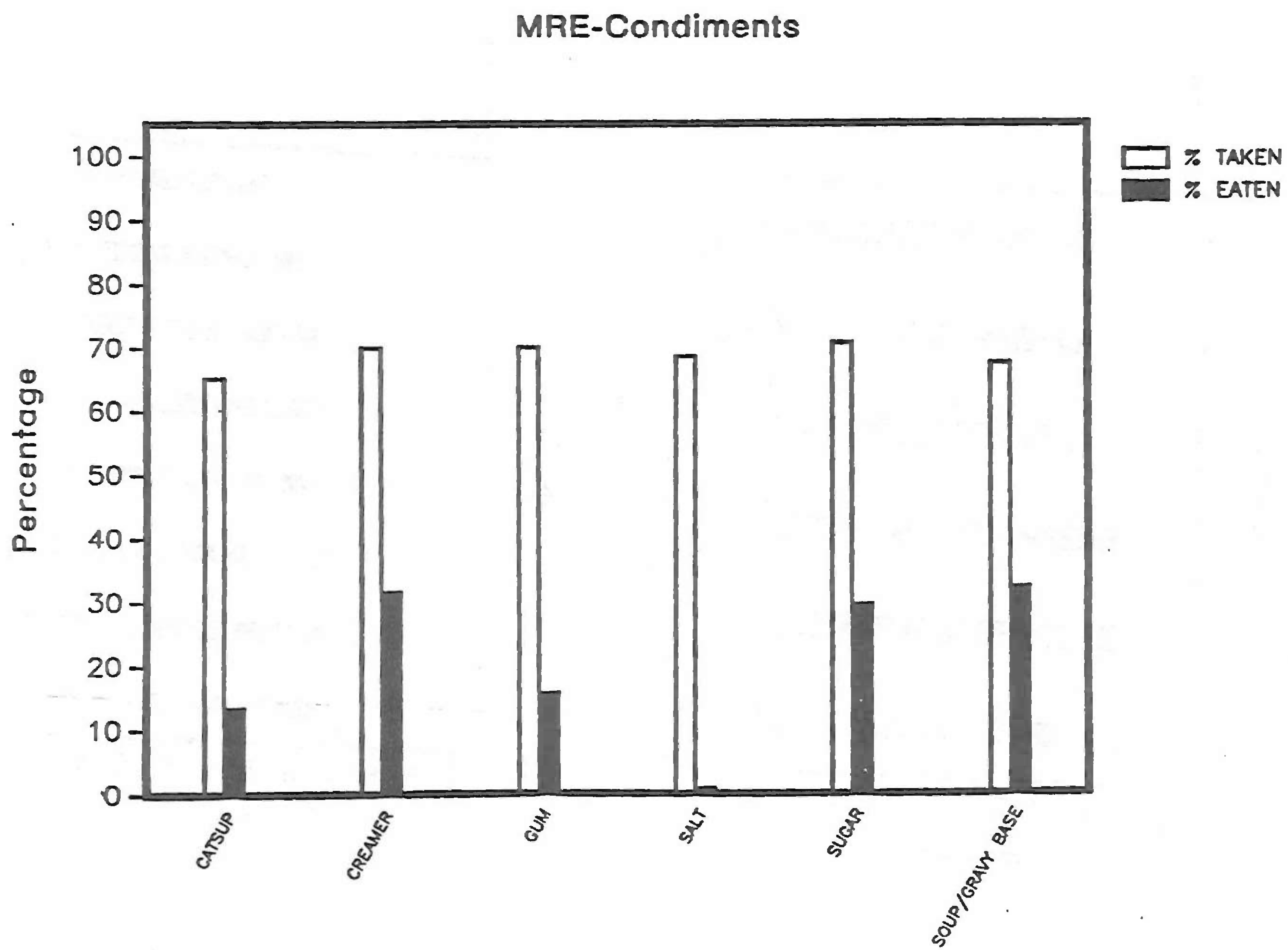

MRE-Condiments
Percentage
100
90
80
70
60
50
40
30
20
10
0
% TAKEN
% EATEN
CATSUP
CREAMER
GUM
SALT
SUGAR
SOUP/GRAVY BASE

Figure 28

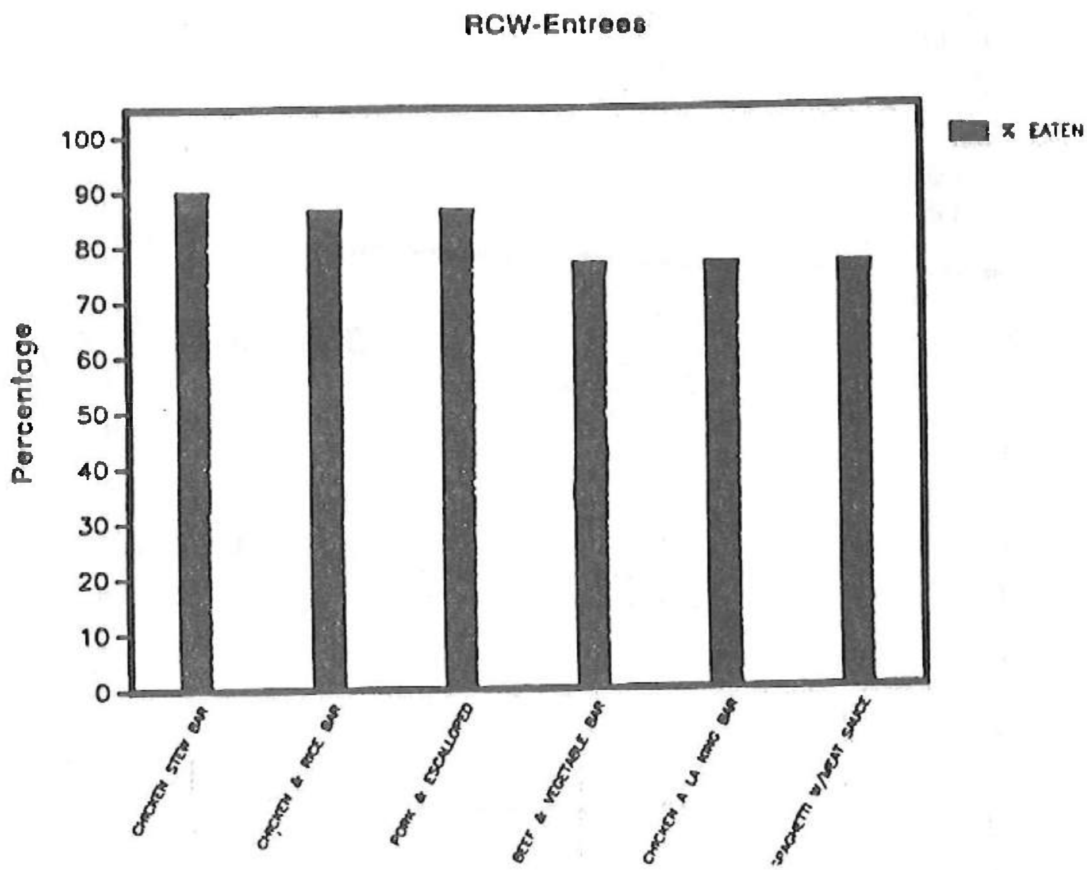


Figure 29

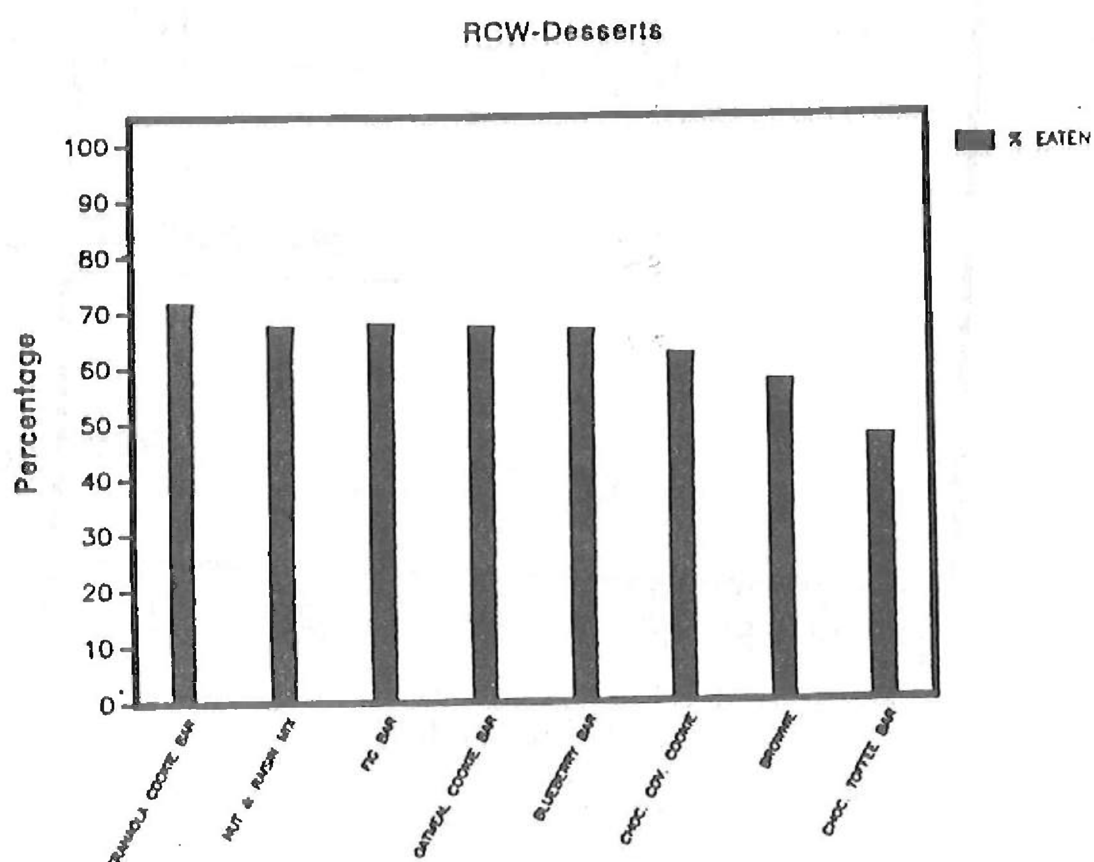


Figure 30

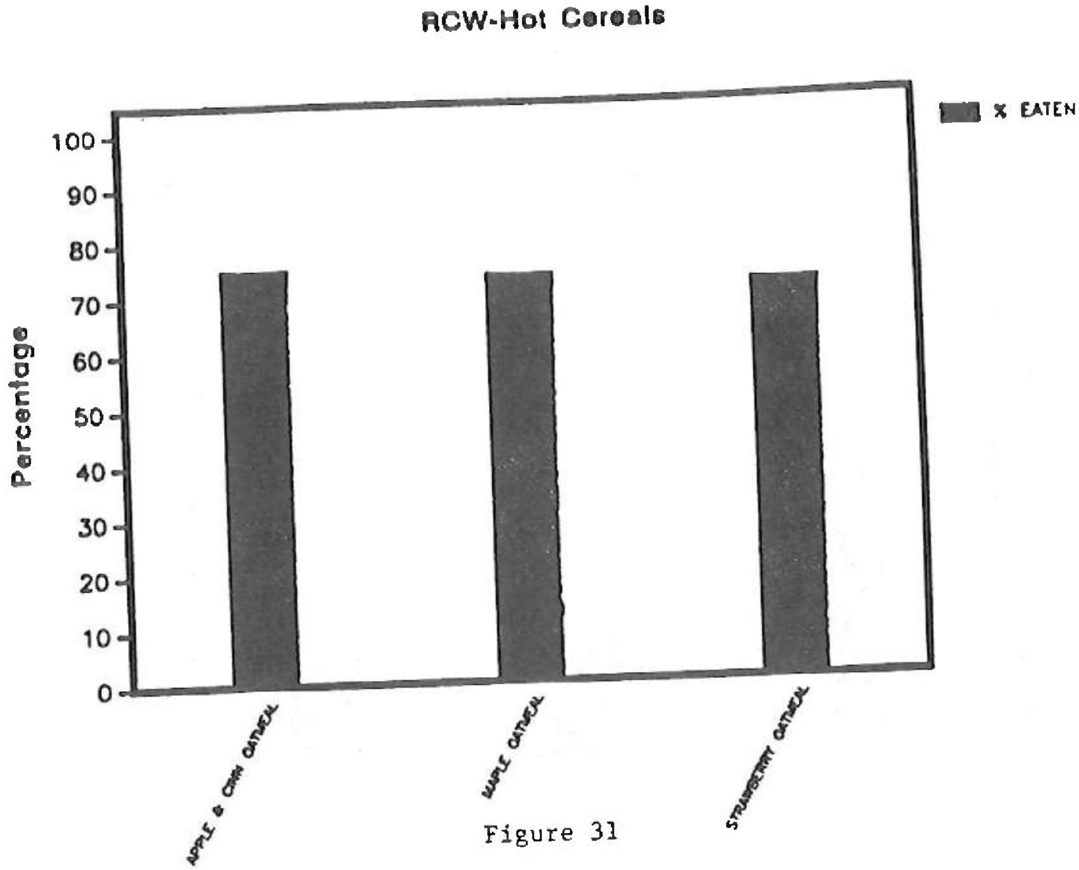


Figure 31

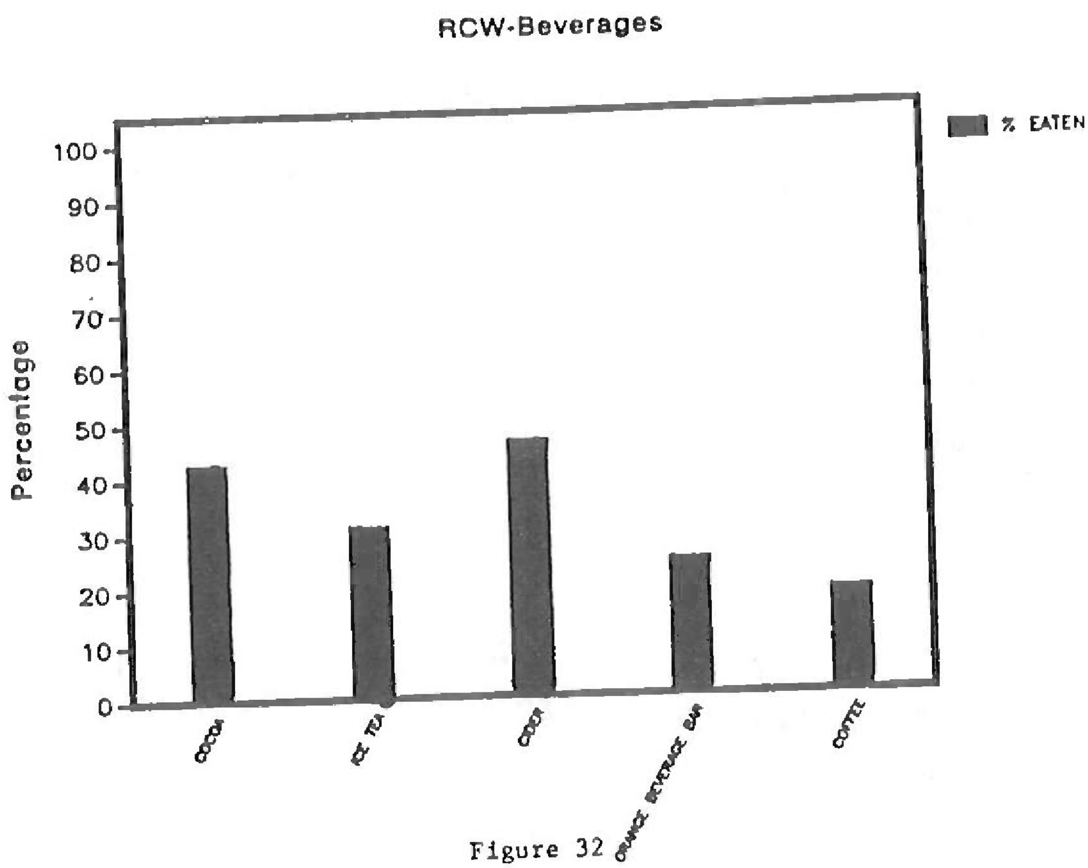


Figure 32

RCW-Soups

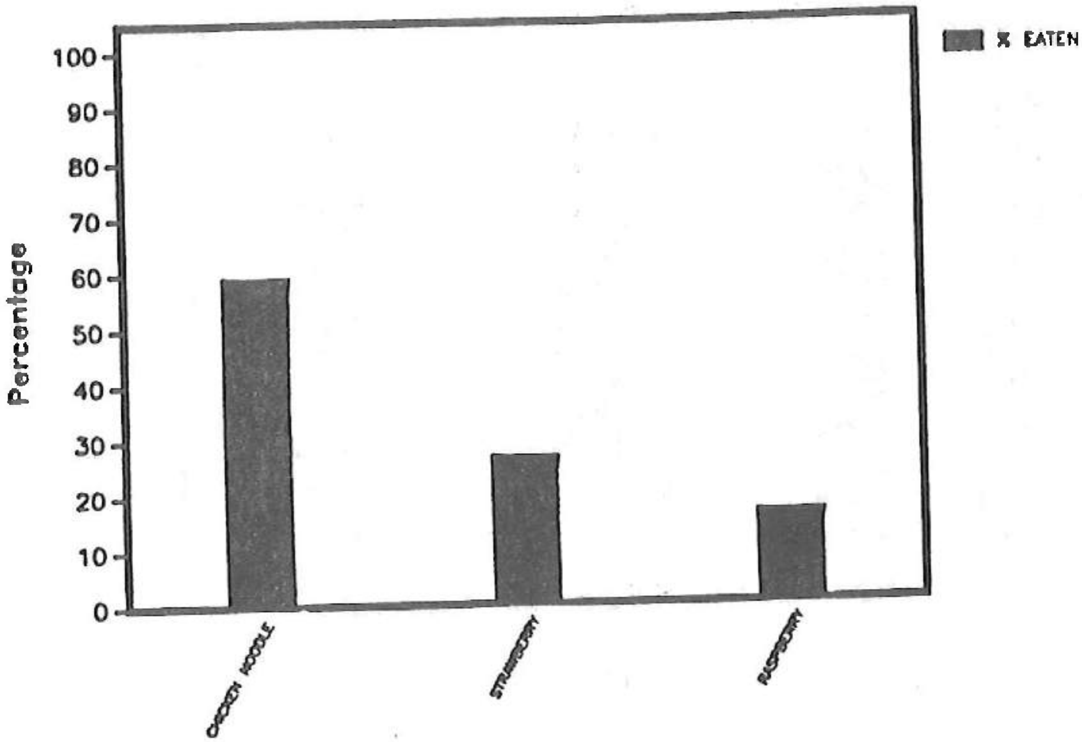


Figure 33

RCW-Condiments

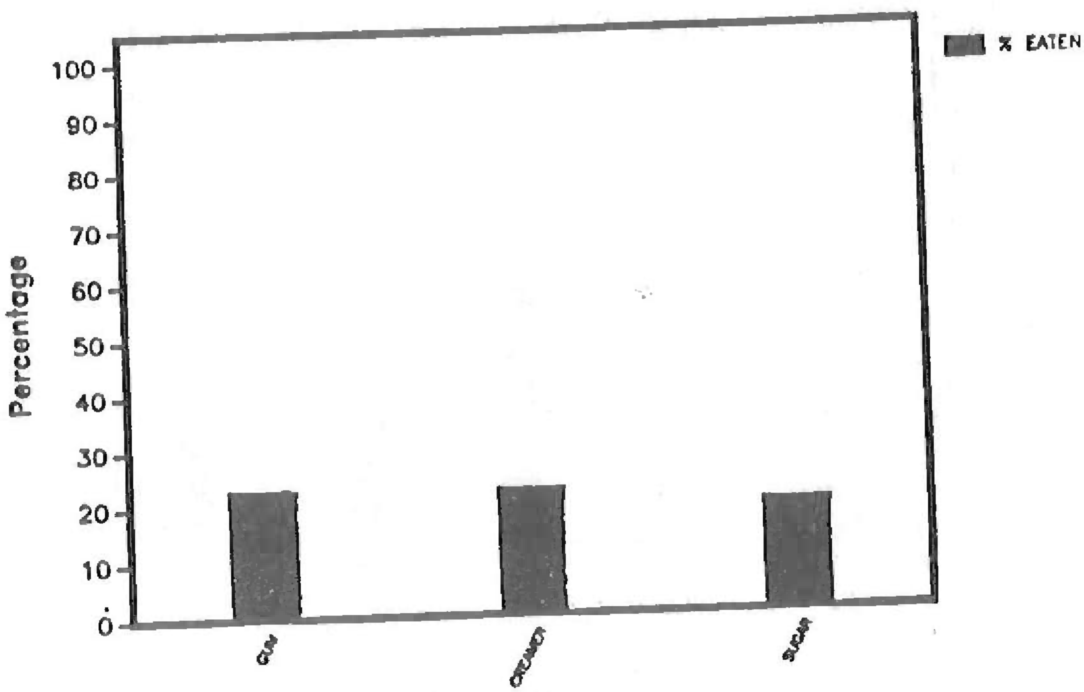
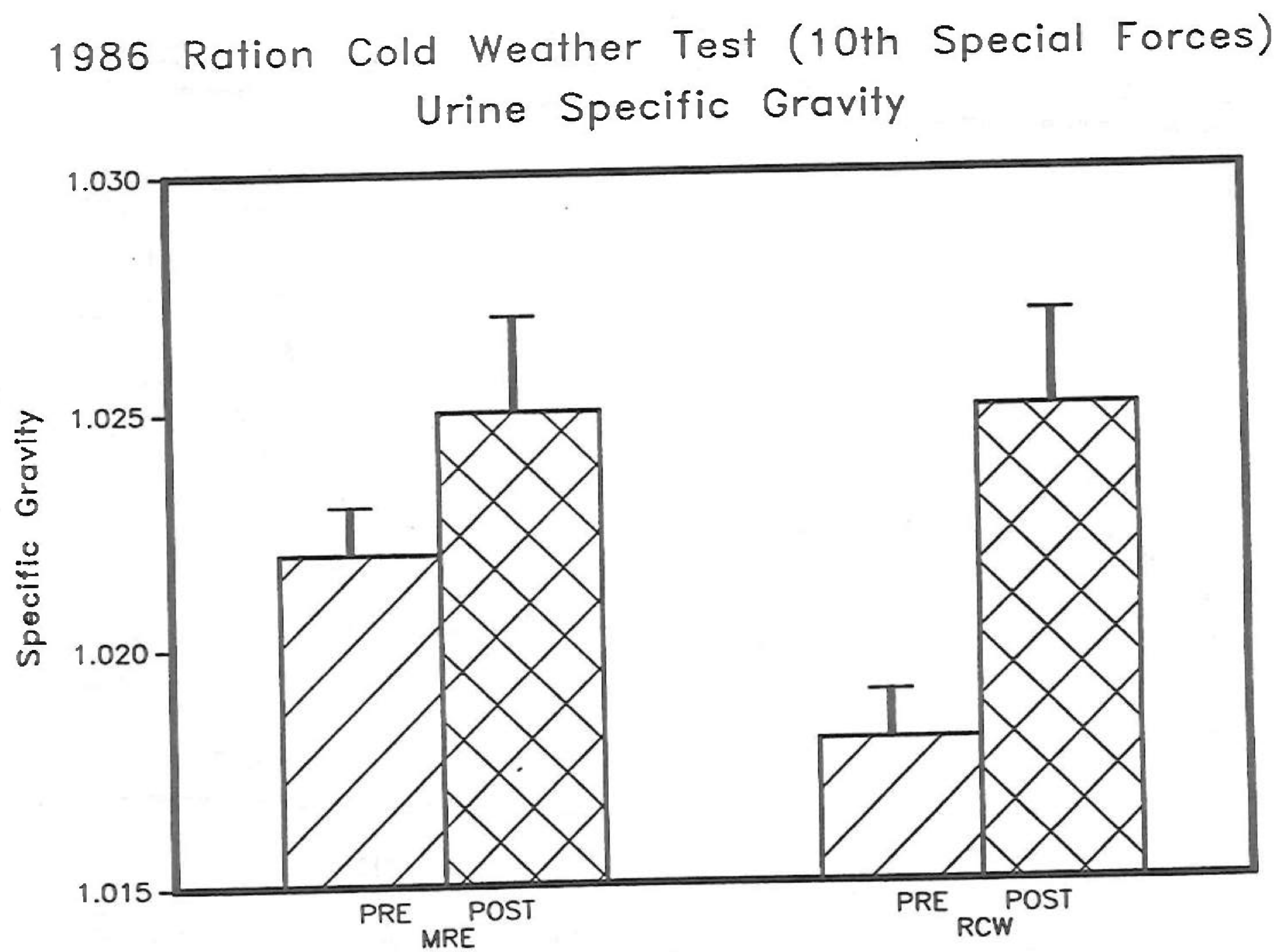


Figure 34



1986 Ration Cold Weather Test (10th Special Forces)
Urine Specific Gravity
Specific Gravity
1.030
1.025
1.020
1.015
PRE
POST
MRE
PRE
POST
RCW

Figure 35

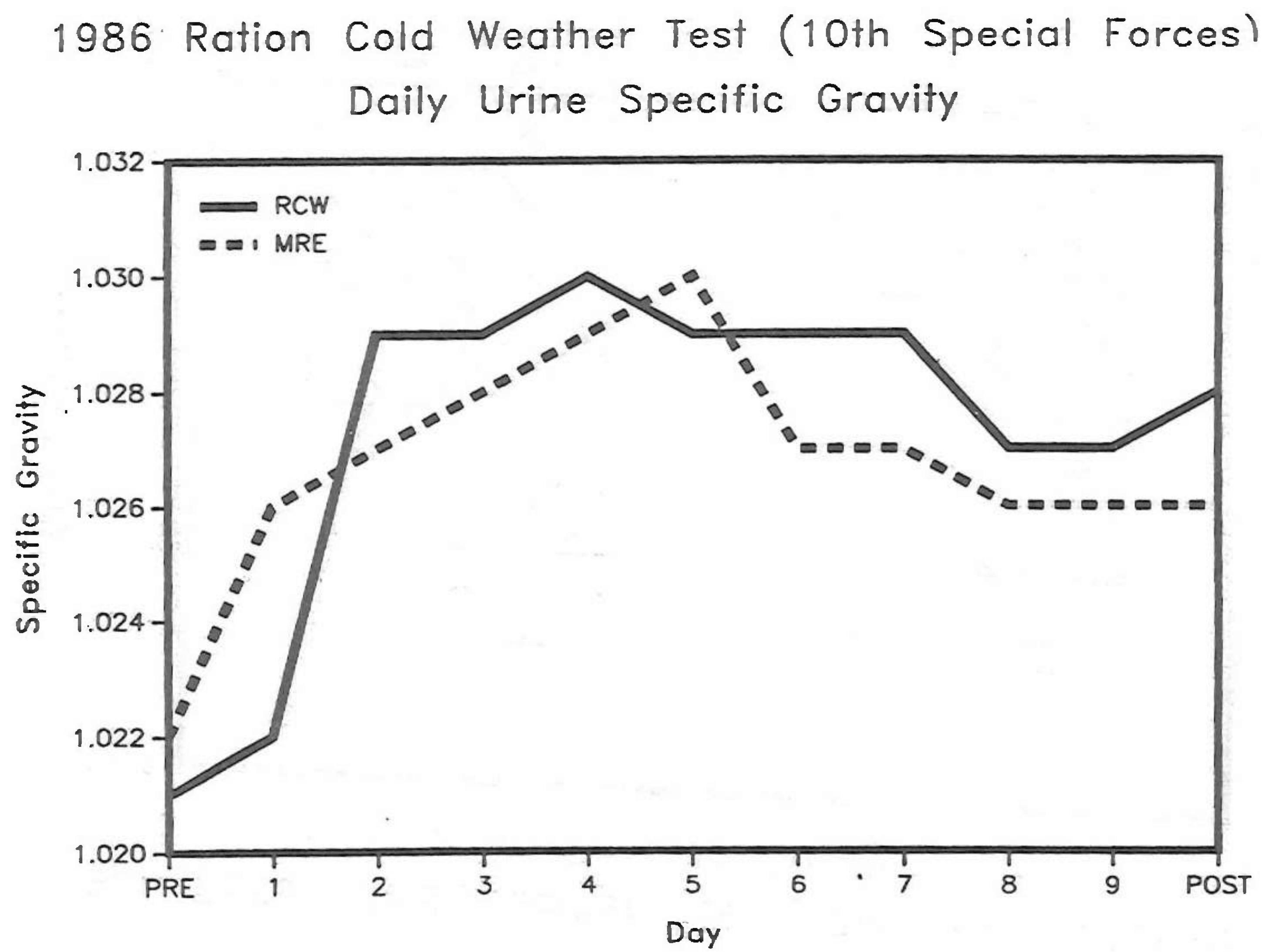

1986 Ration Cold Weather Test (10th Special Forces)
Daily Urine Specific Gravity
RCW
MRE
Specific Gravity
1.032
1.030
1.028
1.026
1.024
1.022
1.020
PRE
1
2
3
4
5
6
7
8
9
POST
Day

Figure 36

1986 Ration Cold Weather Test (10th Special Forces)

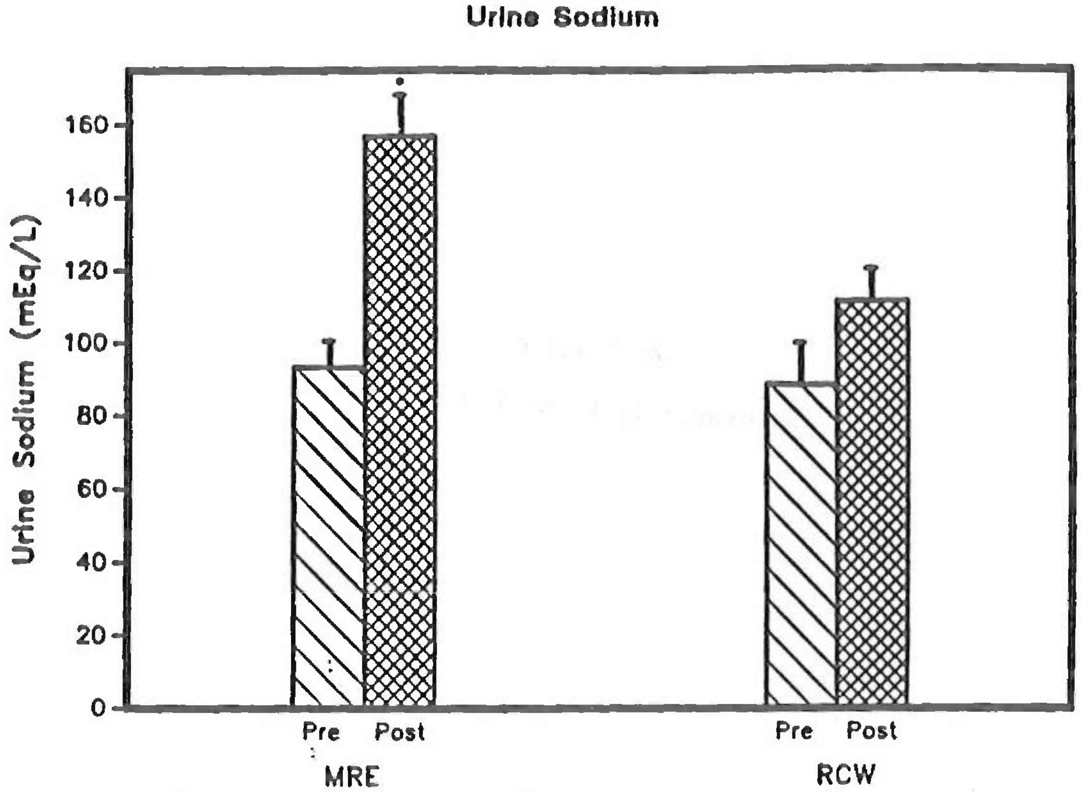


Figure 37

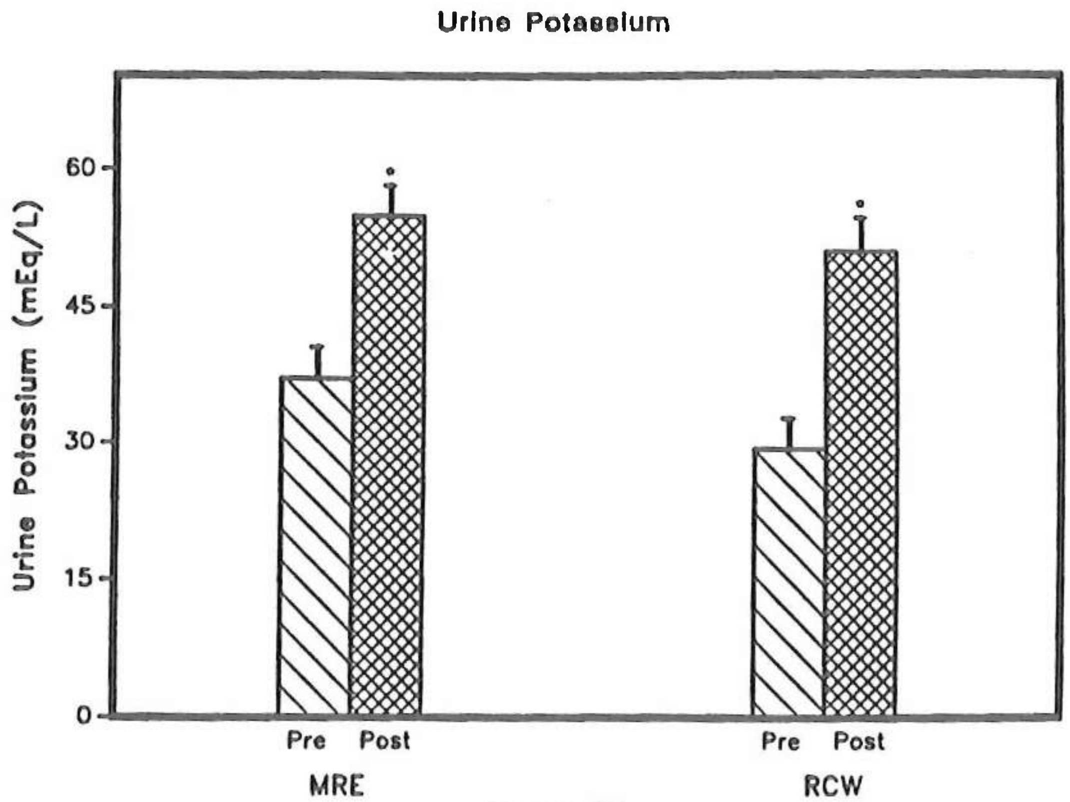


Figure 38

Appendix 1

Description of the Ration Cold Weather

STRNC-WTP

Product Development & Engineering Branch
Food Technology Division
Food Engineering Directorate
Ms. Vicki A. Loveridge
February 1986

FACT SHEET

SUBJECT: Ration, Cold Weather

1. In January 1983, a program was established at Natick R&D Center to develop a 4500 kilocalorie operational Ration, Cold Weather (RCW). The requirement originated with the Marine Corps, which annually deploys units to Norway for cold weather training and has responsibilities for defense of the Northern Flank of NATO in the event of hostilities. Subsistence items/rations presently available are deficient in that they are too bulky or heavy and the high water content makes them susceptible to freezing. Frozen rations have caused hypothermia, severe stomach cramps, dehydration and lpss of appetite during previous cold weather training. The only subsistence freeze-dried ration, the Food Packet, Long Range Patrol, does not meet the volume or caloric requirement.

2. The critical features of the Ration, Cold Weather (RCW), previously known as the Arctic Ration, per Marine Corps requirements are:

a. Provides 4500 kilocalories.

b. Components do not freeze.

c. Provides entrees, snacks, and numerous hot drinks.

d. External packaging shall be flat, flexible and waterproof.

e. Convenient to use.

f. Significantly lighter and smaller than four Meal, Ready-to-Eat.

g. The mean sodium content per menu of the six menus must be within the guidelines of Army Regulation 40-25.

3. The Food Packet, Assault (FPA) currently under advanced development was the basis for the preliminary work (1981-82) on the RCW. The original configuration consisted of two FPA's and an Arctic supplement which provided the extra calories and drink mixes to help with water discipline. The freeze-dehydrated compressed foods that were developed for the Assault Ration met the critical features needed for the RCW. The packaging system has evolved to two white pouches each about the size of one MRE.

4. The initial field test of the RCW took place in March 1981 in northern Norway using two companies of Marines. This took place during the annual NATO exercise, simulating an assault over the northern flank of the NATO alliance. The experimental company was issued the Arctic Ration (1981 design). The control company was issued the British 24-hour Ration Pack, Arctic (4500 kcal). Data was collected on acceptance, operational characteristics, water consumption, and urine specific gravities. The urine specific gravities will indicate whether water logistics and water discipline are adequate for this type of ration in an arctic environment. Results from this study indicate that this was a feasible and highly acceptable design for an arctic operational ration and that water discipline needs more command emphasis.

5. An in-house test was conducted in the Natick R&D Center's Climatic Chambers by the Naval Submarine Medical Research Lab in the spring of 1983. A quantity of 400 Arctic Rations was assembled in the latest menu configuration with reduced sodium to study human water balance in an arctic environment. Results are available in Report Number 1017, Navy Medical Research and Development Command.

6. The winter 1983 assembly included commercial production of entrees, cereal bars and orange beverage bars and it supplied the Marines with rations for a formal 6-day 200 man test at the 1984 NATO exercise in Norway. Rations were also supplied to the Navy SEALS for informal evaluations in Canada in February 1984 and Alaska in July 1984. In April 1985, the U.S. Army Health Clinic at the Northern Warfare Training Center, Ft Greely, Alaska evaluated the RCW. Results of these evaluations have been used to improve acceptability of the ration and its producibility.

7. The Army Special Forces recently has identified a requirement for an cold weather ration and a Draft Letter Requirement is being staffed. In anticipation of this Army requirement, FY86 Technical Feasibility Test of the AR will be conducted by Cold Regions Test Center, TECOM. The RCW will be tested in direct comparison with the MRE over a minimum 10 day period during which a study of weight gain/loss will be a primary objective. A second test with Special Forces troops will be conducted by the Sciences and Advanced Technology Directorate and U.S. Army Research Institute of Environmental Medicine. This 10 day test will also investigate physiological indicators of water and electrolyte balance.

8. FY86 milestones for the RCW include production of Technical Data Packages for the components and packaging in addition to the actual assembly of RCWs for the field tests. The Ration, Cold Weather is scheduled for Type Classification in FY87 and fielding the following year.

#1 MEAL PACK	PROTEIN (g)	CHO (g)	FAT (g)	WATER (g)	CALORIES	NETWT (g)
Chicken Stew Bars	52.6	43.7	17.8	2.0	545.1	120.0
Oatmeal, Strawberry	10.9	90.5	15.4	6.1	544.2	125.0
Granola Bars	7.5	59.2	14.0	2.8	392.6	86.0
Oatmeal Cookies	7.5	67.9	19.4	3.5	476.4	100.0
Cookies, Choco Covered	2.9	26.1	12.3	0.7	226.7	43.0
Raisinut Crunch	13.9	62.5	29.0	4.2	566.6	112.0
Blueberry Bars	1.6	44.4	5.0	8.5	229.0	60.0
Chocolate Bars	4.6	35.1	14.3	1.4	287.7	56.0
Cider	0.0	47.5	0.0	5.2	190.0	50.0
Orange Beverage Bars	0.5	58.5	0.0	0.4	236.0	60.0
Cocoa Beverage	6.8	58.8	14.5	2.0	392.9	86.0
Lemon Tea	0.1	27.8	0.1	0.1	112.5	28.0
Fruit Soup, Strawberry	0.1	48.6	0.1	1.2	195.7	50.0
Chicken Noodle Soup	3.6	9.8	2.6	0.7	77.0	18.0
Coffee,Cream,Sugar,Gum	0.3	12.3	1.1	0.4	60.3	23.0
	112.9	692.7	145.6	39.2	4532.7	1017.0

#2 MEAL PACK	PROTEIN (g)	CHO (g)	FAT (g)	WATER (g)	CALORIES	NETWT (g)
Beef & Vegetable Bars	41.9	40.9	26.5	2.4	569.1	120.0
Oatmeal, Apple & Cinn	10.2	93.0	12.1	7.3	521.1	125.0
Granola Bars	7.5	59.2	14.0	2.8	392.6	86.0
Oatmeal Cookies	7.5	67.9	19.4	3.5	476.4	100.0
Brownie	3.8	25.1	16.9	3.6	267.7	50.0
Raisinut Crunch	13.9	62.5	29.0	4.2	566.6	112.0
Fig Bars	2.4	41.4	3.9	9.3	210.3	58.0
Chocolate Bars	4.6	35.1	14.3	1.4	287.7	56.0
Cider	0.0	47.5	0.0	5.2	190.0	50.0
Orange Beverage Bars	0.5	58.5	0.0	0.4	236.0	60.0
Cocoa Beverage	6.8	58.8	14.5	2.0	392.9	86.0
Lemon Tea	0.1	27.8	0.1	1.2	112.5	28.0
Fruit Soup, Raspberry	0.1	48.5	0.1	1.3	195.3	50.0
Chicken Noodle Soup	3.6	9.8	2.6	0.7	77.0	18.0
Coffee,Cream,Sugar,Gum	0.3	12.3	1.1	0.4	60.3	23.0
	103.1	688.3	154.4	45.7	4555.5	1022.0

#3 MEAL PACK	PROTEIN (g)	CHO (g)	FAT (g)	WATER (g)	CALORIES	NETWT (g)
Pork & Escall Potato	38.3	47.7	22.6	2.5	547.3	120.0
Oatmeal, Apple & Cinn	10.2	93.0	12.1	7.3	521.1	125.0
Granola Bars	7.5	59.2	14.0	2.8	392.6	86.0
Oatmeal Cookies	7.5	67.9	19.4	3.5	476.4	100.0
Brownie	3.8	25.1	16.9	3.6	267.7	50.0
Raisinut Crunch	13.9	62.5	29.0	4.2	566.6	112.0
Fig Bars	2.4	41.4	3.9	9.3	210.3	58.0
Chocolate Bars	4.6	35.1	14.3	1.4	287.7	56.0
Cider	0.0	47.5	0.0	5.2	190.0	50.0
Orange Beverage Bars	0.5	58.5	0.0	0.4	236.0	60.0
Cocoa Beverage	6.8	58.8	14.5	2.0	392.9	86.0
Lemon Tea	0.1	27.8	0.1	0.1	112.5	28.0
Fruit Soup, Strawberry	0.1	48.6	0.1	1.2	195.7	50.0
Chicken Noodle Soup	3.6	9.8	2.6	0.7	77.0	18.0
Coffee,Cream,Sugar,Gum	0.3	12.3	1.1	0.4	60.3	23.0
	99.5	695.2	150.6	44.5	4534.2	1022.0

#4 MEAL PACK	PROTEIN (g)	CHO (g)	FAT (g)	WATER (g)	CALORIES	NETWT (g)
Chicken a la King	53.7	22.2	33.2	1.8	602.0	120.0
Oatmeal, Maple	10.5	91.9	12.5	7.5	522.7	125.0
Granola Bars	7.5	59.2	14.0	2.8	392.6	86.0
Oatmeal Cookies	7.5	67.9	19.4	3.5	476.4	100.0
Cookies, Choco Covered	2.9	26.1	12.3	0.7	226.7	43.0
Raisinut Crunch	13.9	62.5	29.0	4.2	566.6	112.0
Fig Bars	2.4	41.4	3.9	9.3	210.3	58.0
Chocolate Bars	4.6	35.1	14.3	1.4	287.7	56.0
Cider	0.0	47.5	0.0	5.2	190.0	50.0
Orange Beverage Bars	0.5	58.5	0.0	0.4	236.0	60.0
Cocoa Beverage	6.8	58.8	14.5	2.0	392.9	86.0
Lemon Tea	0.1	27.8	0.1	0.1	112.5	28.0
Fruit Soup, Raspberry	0.1	48.5	0.1	1.3	195.3	50.0
Chicken Noodle Soup	3.6	9.8	2.6	0.7	77.0	18.0
Coffee,Cream,Sugar,Gum	0.3	12.3	1.1	0.4	60.3	23.0
	114.5	669.5	157.0	41.3	4549.0	1015.0

#5 MEAL PACK	PROTEIN (g)	CHO (g)	FAT (g)	WATER (g)	CALORIES	NETWT (g)
Chicken & Rice	59.5	40.6	10.8	1.8	497.1	120.0
Oatmeal, Strawberry	10.9	90.5	14.9	6.2	539.3	125.0
Granola Bars	7.5	59.2	14.0	2.8	392.6	86.0
Oatmeal Cookies	7.5	67.9	19.4	3.5	476.4	100.0
Brownie	3.8	25.1	16.9	3.6	267.7	50.0
Raisinut Crunch	13.9	62.5	29.0	4.2	566.6	112.0
Blueberry Bars	1.6	44.4	5.0	8.5	229.0	60.0
Chocolate Bars	4.6	35.1	14.3	1.4	287.7	56.0
Cider	0.0	47.5	0.0	5.2	190.0	50.0
Orange Beverage Bars	0.5	58.5	0.0	0.4	236.0	60.0
Cocoa Beverage	6.8	58.8	14.5	2.0	392.9	86.0
Lemon Tea	0.1	27.8	0.1	0.1	112.5	28.0
Fruit Soup, Strawberry	0.1	48.6	0.1	1.2	195.7	50.0
Chicken Noodle Soup	3.6	9.8	2.6	0.7	77.0	18.0
Coffee,Cream,Sugar,Gum	0.3	12.3	1.1	0.4	60.3	23.0
	120.7	688.6	142.6	42.0	4520.8	1024.0

#6 MEAL PACK	PROTEIN (g)	CHO (g)	FAT (g)	WATER (g)	CALORIES	NETWT (g)
Spaghetti & Meat Bars	39.2	45.0	28.0	2.3	588.7	120.0
Oatmeal, Maple	10.5	91.9	12.5	7.5	522.7	125.0
Granola Bars	7.5	59.2	14.0	2.8	392.6	86.0
Oatmeal Cookies	7.5	67.9	19.4	3.5	476.4	100.0
Cookies, Choco Covered	2.9	26.1	12.3	0.7	226.7	43.0
Raisinut Crunch	13.9	62.5	29.0	4.2	566.6	112.0
Blueberry Bars	1.6	44.4	5.0	8.5	229.0	60.0
Chocolate Bars	4.6	35.1	14.3	1.4	287.7	56.0
Cider	0.0	47.5	0.0	5.2	190.0	50.0
Orange Beverage Bars	0.5	58.5	0.0	0.4	236.0	60.0
Cocoa Beverage	6.8	58.8	14.5	2.0	392.0	86.0
Lemon Tea	0.1	27.8	0.1	0.1	112.5	28.0
Fruit Soup, Raspberry	0.1	48.5	0.1	1.3	195.8	50.0
Chicken Noodle Soup	3.6	9.8	2.6	0.7	77.0	18.0
Coffee,Cream,Sugar,Gum	0.3	12.3	1.1	0.4	60.3	23.0
	99.2	695.3	152.9	41.0	4554.4	1017.0

RATION, COLD WEATHER February 1986

SUMMARY	PROTEIN (g)	CHO (g)	FAT (g)	CALORIES
MENU #1	112.9	692.7	145.6	4532.7
MENU #2	103.1	688.3	154.4	4555.5
MENU #3	99.5	695.2	150.6	4534.2
MENU #4	114.5	669.5	157.0	4549.0
MENU #5	120.7	695.3	152.9	4520.8
MENU #6	99.2	695.3	152.9	4554.4
Average	108.3	688.3	150.5	4541.1

RATION, COLD WEATHER

Summary	Entrees (kcal)	Oatmeal (kcal)	Bar/Cookie (kcal)	Beverage (kcal)	Soups (kcal)	Coffee (kcal)
Menu #1	545	544	2179	931	272	60
Menu #2	569	521	2701	931	273	60
Menu #3	547	521	2201	931	272	60
Menu #4	602	523	2179	931	273	60
Menu #5	497	539	2220	931	272	60
Menu #6	589	523	2179	931	273	60
Average	558	529	2193	931	273	60

Appendix 2

Food Consumption Record Forms

DAY 2

MRE RATION CONSUMPTION

Please circle the number that indicates how much of each item you ate today. If you ate more than the amounts listed, please write in the total amount consumed.

Please list the amount of water you added to each food or beverage item. Write in "0" if the item is not rehydrated.

ENTREES	CODE	AMOUNT CONSUMED (by package)					WATER (in canteen cups)
Beef w/barbeque sauce	35	1/4	1/2	3/4	1	______	______
Beef w/gravy	39	1/4	1/2	3/4	1	______	______
Beef w/spiced sauce	43	1/4	1/2	3/4	1	______	______
Beef patties	34	1/4	1/2	3/4	1	______	______
Beef stew	36	1/4	1/2	3/4	1	______	______
Chicken ala king	40	1/4	1/2	3/4	1	______	______
Frankfurters	37	1/4	1/2	3/4	1	______	______
Ham/chicken loaf	33	1/4	1/2	3/4	1	______	______
Ham slices	42	1/4	1/2	3/4	1	______	______
Meatballs w/barbeque sauce	41	1/4	1/2	3/4	1	______	______
Pork sausage patties	32	1/4	1/2	3/4	1	______	______
Turkey w/gravy	38	1/4	1/2	3/4	1	______	______
STARCH							
Crackers	48	1/4	1/2	3/4	1	______	______
Beans w/tomato sauce	46	1/4	1/2	3/4	1	______	______
Potato patty	61	1/4	1/2	3/4	1	______	______
SPREAD							
Cheese	31	1/4	1/2	3/4	1	______	______
Jelly	73	1/4	1/2	3/4	1	______	______
Peanut butter	47	1/4	1/2	3/4	1	______	______
FRUIT							
Applesauce	57	1/4	1/2	3/4	1	______	______
Mixed fruits	60	1/4	1/2	3/4	1	______	______
Peaches	59	1/4	1/2	3/4	1	______	______
Strawberries	58	1/4	1/2	3/4	1	______	______
DESSERT							
Brownie	51	1/4	1/2	3/4	1	______	______
Cherry nut cake	52	1/4	1/2	3/4	1	______	______
Chocolate covered cookie	49	1/4	1/2	3/4	1	______	______
Fruitcake	54	1/4	1/2	3/4	1	______	______
Maple nut cake	53	1/4	1/2	3/4	1	______	______
Orange nut cake	56	1/4	1/2	3/4	1	______	______
Pineapple nut cake	50	1/4	1/2	3/4	1	______	______
Chocolate nut cake	55	1/4	1/2	3/4	1	______	______
BEVERAGE							
Cocoa Powder	63	1/4	1/2	3/4	1	______	______
Coffee	64	1/4	1/2	3/4	1	______	______
Cream substitute	30	1/4	1/2	3/4	1	______	______
Sugar	74	1/4	1/2	3/4	1	______	______
OTHER							
Catsup	62	1/4	1/2	3/4	1	______	______
Gravy base (soup mix)	29	1/4	1/2	3/4	1	______	______
Candy (all types)	76	1/4	1/2	3/4	1	______	______
Gum	78	1/4	1/2	3/4	1	______	______
Salt	77	1/4	1/2	3/4	1	______	______

DAY 2

RATING OF FOOD

Please circle the numbers that indicate how much you liked or disliked the ration item that you ate today.

REASON FOR NOT EATING/FINISHING

Please write in the number of the primary reason that you didn't finish an item or did not eat the item at all. If your primary reason is not listed, Write it in.

1. Spilled
2. Left behind
3. Feel full
4. Tasted bad
5. Dieting
6. Looked bad
7. Too bland
8. Traded
9. Unable to heat
10. Not enough water
11. Unfamiliar/strange food
12. Smelled bad
13. Too salty
14. Saved for later meal
15. Not enough time
16. Too much trouble

	CODE	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like/Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	DID NOT EAT	DID NOT FINISH
ENTREES												
Beef w/barbeque sauce	35	1	2	3	4	5	6	7	8	9		
Beef w/gravy	39	1	2	3	4	5	6	7	8	9		
Beef w/spiced sauce	43	1	2	3	4	5	6	7	8	9		
Beef patties	34	1	2	3	4	5	6	7	8	9		
Beef stew	36	1	2	3	4	5	6	7	8	9		
Chicken ala king	40	1	2	3	4	5	6	7	8	9		
Frankfurters	37	1	2	3	4	5	6	7	8	9		
Ham/chicken loaf	33	1	2	3	4	5	6	7	8	9		
Ham slices	42	1	2	3	4	5	6	7	8	9		
Meatballs w/barbeque sauce	41	1	2	3	4	5	6	7	8	9		
Pork sausage patties	32	1	2	3	4	5	6	7	8	9		
Turkey w/gravy	38	1	2	3	4	5	6	7	8	9		
STARCH												
Crackers	48	1	2	3	4	5	6	7	8	9		
Beans w/tomato sauce	46	1	2	3	4	5	6	7	8	9		
Potato patty	61	1	2	3	4	5	6	7	8	9		
SPREAD												
Cheese	31	1	2	3	4	5	6	7	8	9		
Jelly	73	1	2	3	4	5	6	7	8	9		
Peanut butter	47	1	2	3	4	5	6	7	8	9		
FRUIT												
Applesauce	57	1	2	3	4	5	6	7	8	9		
Mixed fruits	60	1	2	3	4	5	6	7	8	9		
Peaches	59	1	2	3	4	5	6	7	8	9		
Strawberries	58	1	2	3	4	5	6	7	8	9		
DESSERT												
Brownie	51	1	2	3	4	5	6	7	8	9		
Cherry nut cake	52	1	2	3	4	5	6	7	8	9		
Chocolate covered cookie	49	1	2	3	4	5	6	7	8	9		
Fruitcake	54	1	2	3	4	5	6	7	8	9		
Maple nut cake	53	1	2	3	4	5	6	7	8	9		
Orange nut cake	56	1	2	3	4	5	6	7	8	9		
Pineapple nut cake	50	1	2	3	4	5	6	7	8	9		
Chocolate nut cake	55	1	2	3	4	5	6	7	8	9		
BEVERAGE												
Cocoa Powder	63	1	2	3	4	5	6	7	8	9		
Coffee	64	1	2	3	4	5	6	7	8	9		
Cream substitute	30	1	2	3	4	5	6	7	8	9		
Sugar	74	1	2	3	4	5	6	7	8	9		
OTHER												
Catsup	62	1	2	3	4	5	6	7	8	9		
Gravy base (soup mix)	29	1	2	3	4	5	6	7	8	9		
Candy (all types)	76	1	2	3	4	5	6	7	8	9		
Gum	78	1	2	3	4	5	6	7	8	9		
Salt	77	1	2	3	4	5	6	7	8	9		

DAY 2

WATER CONSUMPTION

Circle the total amount of unflavored water that you drink or use during each period. Do not record flavored water such as tea, orange beverage, etc. here. If you drink or use more than two canteens during one period, write the total amount on the line provided.

	DRINKING	OTHER (washing, etc.)
During Breakfast	(10) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(11) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
Between Breakfast and Lunch	(20) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(21) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
During Lunch	(30) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(31) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
Between Lunch and Dinner	(40) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(41) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
During Dinner	(50) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(51) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
Between Dinner and Breakfast	(60) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(61) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens

	DRINKING	OTHER
Daily Total	(70) ________ canteens	(71) ________ canteens

DAY 2

ARCTIC RATION CONSUMPTION

Circle the numbe that indicates how much of each item you ate today. The total amount of each item is sh n in parentheses in bar or package (pkt) units. If you eat an amount that is not listed, write it on the line to the right. For example: If your eat 2 chicken stew bars, circle 2. If you eat 2½ bars, write in 2½. If you eat 5 bars, write in 5.

Please list the amount of water you added to each food or beverage item. Write in "0" if you did not add water to a food you ate.

FOOD ITEM	UNIT	CODE	AMOUNT CONSUMED					WATER (in canteen cups)
ENTREES								
Oatmeal (Apple & Cinn.)	pkt (1)	12	1/4	1/2	3/4	1	______	______
Oatmeal (Maple & Brn Sugar)	pkt (1)	13	1/4	1/2	3/4	1	______	______
Oatmeal (Strawberry)	pkt (1)	14	1/4	1/2	3/4	1	______	______
Chicken Stew	bar (4)	03	1	2	3	4	______	______
Beef & Vegetable	bar (4)	04	1	2	3	4	______	______
Pork & Esc. Potato	bar (4)	05	1	2	3	4	______	______
Chicken Ala King	bar (4)	06	1	2	3	4	______	______
Spaghetti w/Meat Sauce	bar (4)	08	1	2	3	4	______	______
Chicken & Rice	bar (4)	07	1	2	3	4	______	______
DRINKS/SOUPS								
Lemon Tea	pkt (2)	23	1	2			______	______
Orange Beverage	bar (1)	22	1/4	1/2	3/4	1	______	______
Chicken Soup	pkt (1)	10	1/4	1/2	3/4	1	______	______
Fruit Soup Strawberry	pkt (1)	27	1/4	1/2	3/4	1	______	______
Fruit Soup Raspberry	pkt (1)	28	1/4	1/2	3/4	1	______	______
Cocoa	pkt (2)	01	1	2			______	______
Coffee	pkt (1)	24	1	2			______	______
Cream	pkt (1)	02	1				______	______
Sugar	pkt (1)	25	1				______	______
SNACKS								
Cookies, Choc. Cov.	pkt (1)	17	1/2	1			______	______
Brownie	bar (1)	19	1/4	1/2	3/4	1	______	______
Raisinut Crunch	pkt (2)	11	1/2	1	1 1/2	2	______	______
Granola	bar (2)	15	1/2	1	1 1/2	2	______	______
Oatmeal Cookie	bar (2)	16	1	2			______	______
Chocolate	bar (2)	26	1	2			______	______
Blueberry	bar (3)	18	1	2	3		______	______
Fig	bar (2)	20	1	2			______	______
Chewing gum	pkt (1)	75	1				______	______
______________	______						______	______

DAY 2

RATING OF FOOD

Please circle the numbers that indicate how much you liked or disliked the ration item that you ate today.

REASONS FOR NOT EATING/FINISHING

Please write in the number of the primary reason that you didn't finish an item or did not eat the item at all. If your primary reason is not listed, write it in.

1. Spilled
2. Left behind
3. Feel full
4. Tasted bad
5. Dieting
6. Looked bad
7. Too bland
8. Traded
9. Unable to heat
10. Not enough water
11. Unfamiliar/strange food
12. Smelled bad
13. Too salty
14. Saved for later meal
15. Not enough time
16. Too much trouble

ENTREES	CODE	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like/Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely	DID NOT EAT	DID NOT FINISH
Oatmeal (Apple & Cinn.) (pkt)	12	1	2	3	4	5	6	7	8	9		
Oatmeal (Mpl & Brn Sgr) (pkt)	13	1	2	3	4	5	6	7	8	9		
Oatmeal (Strawberry) (pkt)	14	1	2	3	4	5	6	7	8	9		
Chicken Stew (bars)	03	1	2	3	4	5	6	7	8	9		
Beef & Vegetable (bars)	04	1	2	3	4	5	6	7	8	9		
Pork & Esc. Potato (bars)	05	1	2	3	4	5	6	7	8	9		
Chicken Ala King (bars)	06	1	2	3	4	5	6	7	8	9		
Spaghetti w/Meat Sauce (bars)	08	1	2	3	4	5	6	7	8	9		
Chicken & Rice (bars)	07	1	2	3	4	5	6	7	8	9		
DRINKS/SOUPS												
Lemon Tea (pkt)	23	1	2	3	4	5	6	7	8	9		
Orange Beverage (bar)	22	1	2	3	4	5	6	7	8	9		
Chicken Soup (pkt)	10	1	2	3	4	5	6	7	8	9		
Fruit Soup Strawberry (pkt)	27	1	2	3	4	5	6	7	8	9		
Fruit Soup Raspberry (pkt)	28	1	2	3	4	5	6	7	8	9		
Cocoa (pkt)	01	1	2	3	4	5	6	7	8	9		
Coffee (pkt)	24	1	2	3	4	5	6	7	8	9		
Cream (pkt)	02	1	2	3	4	5	6	7	8	9		
Sugar (pkt)	25	1	2	3	4	5	6	7	8	9		
SNACKS												
Cookie, Choc. Cov. (each)	17	1	2	3	4	5	6	7	8	9		
Brownie (bar)	19	1	2	3	4	5	6	7	8	9		
Raisinut Crunch (pkg)	11	1	2	3	4	5	6	7	8	9		
Granola (bar)	15	1	2	3	4	5	6	7	8	9		
Oatmeal Cookie (bars)	16	1	2	3	4	5	6	7	8	9		
Chocolate (bars)	26	1	2	3	4	5	6	7	8	9		
Blueberry (bars)	18	1	2	3	4	5	6	7	8	9		
Fig (bars)	20	1	2	3	4	5	6	7	8	9		
Chewing Gum (pkt)	75	1	2	3	4	5	6	7	8	9		
(Other) ______	79	1	2	3	4	5	6	7	8	9		

DAY 2

WATER CONSUMPTION

Circle the total amount of unflavored water that you drink or use during each period. Do not record flavored water such as tea, orange beverage, etc. here. If you drink or use more than two canteens during one period, write the total amount on the line provided.

	DRINKING	OTHER (washing, etc.)
During Breakfast	(10) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(11) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
Between Breakfast and Lunch	(20) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(21) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
During Lunch	(30) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(31) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
Between Lunch and Dinner	(40) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(41) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
During Dinner	(50) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(51) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens
Between Dinner and Breakfast	(60) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens	(61) ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 or ___ canteens

	DRINKING	OTHER
Daily Total	(70) ___ canteens	(71) ___ canteens

BODY FLUID SCALE

1. How LIGHT or DARK is your urine today? (circle one):

EXTREMELY LIGHT	MODERATELY LIGHT	SLIGHTLY LIGHT	NEITHER LIGHT NOR DARK	SLIGHTLY DARK	MODERATELY DARK	EXTREMELY DARK
1	2	3	4	5	6	7

2. Rate the COLOR of your urine as it has occurred today. (circle one):

LIGHT YELLOW	DARK YELLOW	ORANGE	BROWN
1	2	3	4

3. Are you urinating more or less OFTEN than usual? (circle one)

EXTREMELY MORE	MODERATELY MORE	SLIGHTLY MORE	NEITHER MORE NOR LESS	SLIGHTLY LESS	MODERATELY LESS	EXTREMELY LESS
1	2	3	4	5	6	7

4. Is the AMOUNT you are urinating more or less than usual? (circle one):

EXTREMELY MORE	MODERATELY MORE	SLIGHTLY MORE	NEITHER MORE NOR LESS	SLIGHTLY LESS	MODERATELY LESS	EXTREMELY LESS
1	2	3	4	5	6	7

5. Does your MOUTH feel DRY?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

6. Does your SKIN feel LOOSE or LIMP?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

7. Are you THIRSTY?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

Appendix 3

Daily Urine Dipstick Chemistry Log Book

NAME ____________________ TEST SUBJECT # ____________________

URINE

DATE	SPECIFIC GRAVITY 1.000-1.030							KETONES NEG-160						COMMENTS (ABNORMAL READINGS)
	1.000	05	10	15	20	25	30	NEG	5	15	40	80	160	

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